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Principles of Surgery

BY

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ORIGINAL ILLUSTRATIONS

PHILADELPHIA AND LONDON
W. B. SAUNDERS COMPANY
1913

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PRINTED IN AMERICA

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TO
THE MEN I HAVE TAUGHT

PREFACE

THE purpose in writing this book has been to put the fundamental facts before the student and the physician in a simple and logical way, and thereby to lay a foundation upon which an intelligent understanding of the immense details of practical work may be built. While the title of the book is "Principles of Surgery," its real significance would possibly be more correctly expressed by the single word "Principles"; for while the text presents the facts upon which surgical diagnosis and treatment rest, it at the same time covers elemental teachings which as surely concern every other branch of medical practice, especially inasmuch as the majority of surgical cases must come at first into the hands of the practitioner of medicine.

I desire to express my especial thanks to Dr. William M. McCabe for permission to make illustrations from the cases in the Nashville City Hospital, to Dr. James Ewing who placed at my disposal the Pathological Department of Cornell University, and to Dr. Herman Spitz for making microphotographs.

W. A. BRYAN.

NASHVILLE, TENNESSEE,
November, 1913.

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PRINCIPLES OF SURGERY

CHAPTER I

SURGICAL BACTERIA

Bacteria are microscopic unicellular organisms belonging to the vegetable kingdom. They are also known as germs, microbes, or micro-organisms: the last name embraces also the microscopic organisms belonging to the animal kingdom, known as protozoa, and has, therefore, a wider application, while the first three synonyms given apply distinctly to those micro-organisms embraced in the definition.

It belongs to bacteriology to distinguish one species of bacteria from another, yet this distinction so closely concerns the surgeon in a practical way that the means of distinction are given here. They are differentiated by possessing different groups of characteristics.

Shape.—The appearance of bacteria is very variable for different species, although this, by no means, is sufficient of itself for the classification of any single species. One shape frequently seen is spheric, another elongated or rod-like; of the former, some are apparently flattened on the surface, as if a segment had been removed from it, while the latter may be straight or curved, with the ends either rounded or square. Still others are spiral in shape, and are more elongated than the rod-shaped germs.

Arrangement.—As seen under the microscope, certain bacteria show no tendency to group themselves after a definite fashion, and others are observed habitually to form such grouping as to classify them instantly with a small number of species possessing this trait. The arrangement is in pairs, chains, or bunches, the latter being usually illustrated by comparison to a bunch of grapes. In all these three forms of arrangement there is no necessary connection between the associated germs—it results from their habit of growth —and so it is usual to find many individuals on the slide showing no such grouping.

Size.—The size of bacteria is more variable than their shape. Some are easily discovered with a one-sixth lens, while other known organisms require the most delicate staining to be seen with the most powerful microscope under the most favorable circumstances; there are possibly ultramicroscopic bacteria of which we have no knowledge.

Motion.—There are many species that have the power of motion, and thus the ability to convey themselves in their medium from one point to another. Such motion is accomplished by means of very delicate processes from their surface, which, by a kind of ciliary movement, are able to drive the germs about through the medium. These cilia, or flagella, may be few, or so numerous as to give a distinctly hairy appearance, as seen in some of the non-surgical bacteria; the cilia are situated either on the ends or sides of the bacteria, and are rarely seen except on the rod-shaped or spiral varieties, although some of the cocci have them. The presence of flagella is no assurance that the germs possessing them are motile. This phenomenon of motility is made of service in the diagnosis of disease, as illustrated by the clumping of bacteria in Widal's test for typhoid bacilli. Another motion, not physiologic, as that just described, but physical, is seen in small non-motile bodies. They dance around in a minute orbit without being removed from their immediate situation, and the motion depends for its causation on purely outside influences of a physical or a physicochemic nature. It is known as Brownian movement.

Color.—Pigments are produced by a few surgical bacteria; the greater number of color producers, however, belong to the non-pathogenic group. Bacillus pyocyaneus produces a greenish-blue pigment, soluble in the medium in which it grows, and made up of two distinct pigments, a blue and a green, either of which may be produced at will and the other excluded, by alteration of the medium; Staphylococcus aureus and citreus produce an orange- and a lemon-colored pigment respectively, hence their names. The pigments are not found in the germ; therefore, they are colorless; but it probably results from the combination of by-products of the micro-organisms either with elements of the medium or of the atmosphere.

Mode of Growth.—Numerous factors are embraced under this caption. The medium favorable to the development of one micro-organism may be positively refused by another. One germ grows on the surface of the medium, while another grows only from stabs; one liquefies a congealed medium, another does not; one grows only in the presence of oxygen, another only in its absence; one grows into large, readily visible colonies, another into colonies so small as to be scarcely visible; one produces gas in its growth, another none; one develops into distinct colonies in a few hours, another requires several weeks to manifest evidence of colony formation; one grows vigorously through comparatively wide ranges of temperature, another must be nursed cautiously at a very uniform temperature for good results.

Stains.—The stains which are capable of use in the discovery of bacteria constitute a most important element in their detection. So valuable is this that a large number can be differentiated in a practical manner by staining alone. The subject of stains is so long, and so necessary to be learned in detail, that reference can only be made to any standard work on bacteriology. It is only necessary for the present purpose to call attention to this as one of the methods used in differentiation of micro-organisms.

Reproduction.—Bacteria multiply with exceedingly great rapidity under circumstances favorable to their growth. The average time required for a new germ to develop into its adult state and produce other germs is something near an hour. Some of them may pass completely through their generation in as brief a period as twenty minutes, others requiring a much longer time than an hour. So it may be stated here that it is reasonable to suppose some micro-organisms may produce disease in a much briefer period of time after their entrance into the tissues of the body than others. As will be seen later on, this cannot depend solely on the rate of reproduction. The most frequent means of reproduction of bacteria is by fission, a process by which the bacterium is converted into more than one. Unlike the reproduction of higher orders of organisms, in which the parent plant or animal may deliver its offspring without sacrifice of parental identity, bacteria lose their identity in the production of their offspring; they are converted or divided into new individuals. The usual number of germs resulting from the division of the parent germ is two; when this is the case the process is spoken of as binary fission, or binary cell-division.

Spores.—Bacteria may be produced by spores. They do not multiply by spore formation, for it is highly probable that, when circumstances arise under which spores may be produced, many of the germs fail to produce them; it is further true that a single germ usually produces only a single spore, so that multiplication becomes an impossibility. A spore is the form a germ assumes when circumstances become unfavorable to the existence of the germ, if these circumstances do not arise with such rapidity as to preclude the possibility of spore formation. Spores are smaller than the germs out of which they come, they have a denser, tougher capsule, and offer much greater resistance to destructive agencies than the germ. They have no need for the presence of certain environments which are essential to the life and activity of the germ, except that they cannot withstand intense heat, although they are much more resistant to this than the germs themselves are. The spore, therefore, in a way, assumes the same relation to the germ that the seed does to the plant; in another respect it is entirely different. The seed of the plant is developed for the purpose of carrying the species through seasons or circumstances in which the plant could not survive; it has no needs, and is undisturbed by such environment; when the circumstances alter so as to favor the growth of the plant the seed is converted into a new plant; so far, the spore is exactly similar. On the other hand, a single plant produces many seeds and multiplication of the species results; here the spore differs; it preserves indefinitely but does not multiply the species. Many bacteria are incapable of spore production; others produce them only under severe provocation; still others produce them habitually, even under circumstances favorable to flourishing growth. The tetanus Bacillus and bacillus anthracis are the chief examples of habitual spore production among surgical bacteria.

Essential Life Conditions.—For the proper development of bacteria, their multiplication, the elaboration of their poisonous by-products, and hence the production of disease, certain conditions must be fulfilled, without any one of which no harm can come. The conditions necessary for the development of all classes of germs are called *essential life conditions.* They are *proper temperature, moisture,* and *nourishment,* or *culture-medium.* The range of temperature may vary through several degrees; below this they become inactive, although they are not destroyed even by excessive cold; above it, too, they become inactive, and if the increase of heat is sufficient they are killed thereby. It is a truism to state that germs capable of pathogenic activity must be able to live and multiply successfully within the ranges of temperature of the living body. In a completely dry state germs do not multiply, however long they may live; hence, moisture is necessary; it is present in all artificial culture-media, and is abundantly supplied in every tissue of the body subject to microbic invasion. The nourishment of germs is very variable, some of them flourishing on a great variety of media, others fastidiously accepting only one particular medium and that prepared in the most accurate manner. Pathogenic bacteria must find satisfactory nourishment in the various tissues of the body.

Aërobes and Anaërobes.—Aside from the above conditions, essential to growth of all bacteria, some require additional factors. One will grow in the presence of oxygen, and is, therefore, called an aërobic germ, or simply an aërobe; a second refuses to grow in the presence of oxygen, and is called an anaërobic germ or an anaërobe. If a germ will grow only in the presence of oxygen, it is called an obligate aërobe. If a germ grows only in the absence of oxygen, it is an obligate anaërobe. Most microbes grow in oxygen by preference. Some grow equally well with or without it, and are known as optional or facultative anaërobes.

Considering the above-mentioned requirements, it is easily seen that if any of these necessary conditions could be withheld in practical work the accidents due to infection would be absolutely avoidable; but the body temperature cannot be altered sufficiently to be of value, and the other two items can be controlled only relatively, in so far as it is in the surgeon's power to limit the amount of unnecessary moisture and culture-media by the avoidance of accumulations of body fluids, and by the removal of all devitalized tissues, on which bacteria can flourish with less molestation than they receive in living tissues. It is thus apparent why a wound should be as dry as possible before it is closed, and why the wound that cannot be kept dry must be drained to avoid accumulation of fluids, and why tissues that are certainly devitalized should be removed instead of being allowed to become separated by natural processes. An additional weapon is offered the surgeon in dealing with anaërobes, that is, to secure the presence of oxygen in the field of infection by opening and keeping it exposed to the atmosphere, by removal of accumulations that would prevent such exposure, and by the employment of H_2O_2, which liberates oxygen.

Distribution.—Bacteria are found widely distributed throughout the earth, and no structure subject to ordinary atmospheric and climatic changes is without them. They are more prevalent in certain localities where filth is allowed to accumulate and decompose and where the population is dense. They are, too, more numerous in the warmer seasons of the year. It is a safe statement to assert that no external object is devoid of one or more species. The human body and animal bodies, aquatic and terrestrial, are abundantly supplied. The skin, the hair, the follicles of the skin, the alimentary tract, and the genital tract of females habitually contain great numbers of micro-organisms of many varieties, and the urinary tract contains a few, although urine from healthy individuals should contain few or none, unless it be contaminated in voiding. The alimentary tract contains greater quantities than any other part of the body, a considerable proportion (25 to 30 per cent.) of the weight of each motion being bacteria. Certain bacteria infest certain parts of the body with universal frequency, such as the colon bacillus in the intestine; others may not be universally distributed, but may appear constantly in the cavities of certain individuals; so one may show diphtheric bacteria and another the pneumococcus as an inhabitant of the mouth. Bacteria do not live habitually in the tissues of the body; all, except in disease, are on the skin surface or its accessory glands and follicles, or on the mucous membrane and the channels leading into it. So practically, though the body be covered and lined with bacteria, they remain on or in the cutaneous and mucous surfaces.

It is evident from the above that it is impossible to handle anything without its becoming contaminated, and impossible to find anything, of itself not bactericidal, that can be trusted not to be contaminated. The water, the food, the clothing, the dwellings of man, and he himself are alike affected, none being free from bacteria. Air—that is, dust-free—does not contain germs.

On account of the universal distribution of germs and their presence on objects not especially prepared, it becomes impossible to preserve solutions free from contamination if they are opened and portions removed or added from time to time. Stock solutions, as kept in physicians' offices and in the hospitals, if made in large quantities—as strychnin, morphin, atropin, and cocain—may not only accidentally receive a small number of bacteria from dust and contact of the stopper with unclean fingers or with objects on which it is laid, but these bacteria may multiply in the solution until sufficient numbers are present to cause serious inflammatory or suppurative processes consequent upon hypodermic injection.

Carriers.—Certain pathogenic germs seem to be capable of thriving only on human tissues, and are unable to multiply outside the body except under the most favorable laboratory methods. Therefore, it should be possible to eradicate them from the catalogue of disease producers. They may live for indefinite periods outside the body, but, unless replenished from diseased bodies, must ultimately disappear. Again, the micro-organisms given off during confinement from disease may be so dealt with as to practically destroy them all. A carrier is an infected individual able and at liberty to mingle with other people and follow his vocation, who, though he may or may not show signs of disease, has in his body an infected focus from which periodically or continually the bacteria are given off. It is known that tuberculosis and typhoid fever depend almost entirely for their continuance upon direct or indirect transmission from the diseased to the healthy individual. Individuals known to have pulmonary tuberculosis, tuberculous fistula in ano, or other discharging tuberculous foci are allowed to intermingle with others, and thus they become carriers of tuberculosis. It is with especial reference to typhoid fever that the term "carrier" has gained a place in the nomenclature of medical literature. A typhoid carrier is an individual who has had typhoid fever and recovered from it, but has some structure of his body infected by the Bacillus typhosus in pure or mixed culture. This is usually the gall-bladder or a discharging sinus leading to a diseased bone. The carrier, of necessity, keeps his own person contaminated with typhoid bacilli and distributes them wherever he goes, keeping the process up for indefinite years. As many as 25 or 30 cases of typhoid fever have been produced by a single carrier, who was a cook, and the disease followed her from house to house with unerring certainty. *It deserves to be emphasized that discharging surgical lesions may be distributors of infection as certainly as those in the bile-passages.*

Classification of Bacteria.—Those bacteria entering into prominent interest in surgical work will be given in the classification. Bacteria are fundamentally divided into saprophytic, saprogenic, or non-pathogenic and pathogenic.

A saprophytic germ is one that cannot live in living tissues, whether it can produce disease or not. If it does produce disease, it accomplishes this by its poisons being absorbed into the circulation of the blood or lymph. This is the class of germs producing decomposition, and cannot invade the body and attack living tissues. Hence, whatever mischief they produce must be from without. This group plays an important part in the symptomatology of certain processes, as certain types of moist gangrene and sapremia. Perhaps its most frequent representative in the surgical field is Proteus vulgaris.

A pathogenic germ is one which produces disease by living in or on living tissues. It can invade the body tissues, gain a foothold, grow and multiply, and produce all the types of infective disease. Pathogenic germs may also be able to live on dead or dying tissue.

Pathogenic bacteria are subdivided into cocci and bacilli. A coccus is a spheric-shaped minute germ, or one approximately spheric. A bacillus is a rod-shaped germ; usually its length is several times its breadth.

Cocci are subdivided into diplococci, streptococci, and staphylococci.

Diplococci are arranged in pairs, the chief surgical example of which is the diplococcus of Neisser, or gonococcus, causative of gonorrhea.

Streptococci are arranged in chains of varying length.

Staphylococci are arranged in bunches or groups, often likened to a bunch of grapes.

In the appearance of the above three types under the microscope there is no vital connection between the individuals entering into a group, as might be imagined from the illustrations used, and isolated germs appear in the field with no semblance of grouping.

There are many strains or varieties of streptococci which may be embraced under two headings, namely, Streptococcus pyogenes and Streptococcus erysipelatus, from a surgical standpoint. It is not certain that these are different in kind, but in degree of virulence, for it is known that certain cases of erysipelas are pyogenic, and also that streptococci, in general, are very variable in toxic power; this variability can be controlled by laboratory methods, increasing or diminishing virulence at will.

Streptococci are responsible for many disease conditions, and are capable of exceedingly varied activity. They are especially prone to be responsible for secondary infections, of which they head the list. It is estimated that they may be recovered from the heart's blood of one-third of all dead bodies. Their peptogenic action is less than that of staphylococci; hence, they do not so uniformly produce suppuration; however, the more virulent forms may produce profuse suppuration. Streptococci represent one of the most dreadful, if not the very most dreadful, of the common pathogenic bacteria, owing to their virulence, their rapid multiplication, and their tendency to develop on tissues already infected and crippled by other bacteria, and because of the numerous acute and chronic lesions which they may produce. They may cause erysipelas, septicemia, pyemia, the most rapidly fatal form of peritonitis, where they sometimes produce death within twenty-four hours of their entrance; ulcerative or malignant endocarditis, impetigo contagiosa, streptococcus pneumonia, various inflammations of the throat and tonsils (*e. g.*, follicular tonsillitis), in which latter they may serve as a focal infection and be responsible for various general conditions, as, for example, acute or chronic arthritis (rheumatism); they are usually found in Vincent's angina, in connection with the fusiform bacillus; they are the usual cause of "puerperal fever." They are frequently found as the secondary infection in tubercular processes, especially pulmonary, and are favorable to hemorrhage. Evidence is constantly accumulating that they cause acute articular rheumatism. Recent investigations showed that they were present and the active cause in a large number of cases of pruritus ani and vulvæ.

Staphylococci are of three varieties, aureus, albus, and citreus; the first of these is the most prevalent, and is the common cause of acute abscess and general suppurative conditions. Staphylococcus pyogenes aureus produces a yellow pigment which is very variable, being most intense when the bacteria are grown upon carbohydrate media. It produces two toxins, known as staphylolysin and leukocidin. The other forms, citreus and albus, are less frequently encountered than aureus, and are, except for the color produced, very closely allied to it, being, especially albus, probably less virulent. One form of the albus group deserves especial mention, namely, Staphylococcus epidermidis albus of Welch, which is found in the deeper layers of the human skin, and hence is not removable by the ordinary practical methods of sterilization;

it is often responsible for stitch-hole abscesses; it produces a mild infection as a rule. Staphylococci are especially abundant on and in the human body, and are responsible for the many secondary infections and for most cases of acute periostitis and osteomyelitis.

Bacilli.—The common surgical bacilli are Bacillus tuberculosis, bacillus of tetanus, Bacillus typhosus, Bacillus pyocyaneus, Bacillus pyogenes fetidus, colon bacillus, Bacillus anthracis, Bacillus mallei, bacillus of malignant edema, Bacillus aërogenes capsulatus, Pfeiffer's bacillus, and fusiform bacillus of Vincent's angina.

Bacillus tuberculosis is not a true pyogenic organism, although the caseous material resulting from its action may, even in unmixed infection, disintegrate into "tuberculous pus." It occurs as the sole causative factor in a great number of surgical lesions, usually chronic, particularly of the bones, the lymph-nodes, and the serous cavities. These by no means exhaust the possibilities of tubercular activity. This bacillus, when found in pure culture, produces much less symptomatic disturbance than when a secondary pyogenic infection is added, a frequent occurrence either from accident or from meddlesome interference.

The *bacillus of tetanus* is the typic spore-producing germ as well as the typic surgical anaërobe. The germs seen in a field under the microscope do not all show spores, but a goodly number do, giving them the typic drum-stick appearance, owing to the presence of the spore in the end of the bacillus. It is not pyogenic, but may be aided in its activity by the presence of aërobic micro-organisms, which, by their consumption of oxygen, render the field more completely anaërobic.

Bacillus typhosus is usually thought of as belonging only to internal medicine. It has been discovered, of recent years, with increasing frequency to be causative of surgical lesions. This is much more important now, in the light of investigations of typhoid-carriers, than could have been surmised a few years ago. Bacillus typhosus becomes actively pyogenic at times in pure culture, and, when attacking the osseous system, is peculiarly resistant to surgical methods applicable to similar lesions produced by other bacteria. Its chief surgical interest is due to the readiness with which it attacks bone and the gall-bladder, producing in the latter cholecystitis and gall-stones.

Bacillus pyocyaneus is met with frequently in suppurative wounds. It is pyogenic, and produces a bluish-green pus; the color may be slightly manifest if the pus is in a bulk, but shows itself distinctly and unmistakably on the dressings at the edges of the soiled area where free access of air is possible. By artificial processes it is possible to cause this germ to produce only the blue or the green pigment. Grown on egg-white the green pigment appears with a fluorescent effect, but on a solution of pure peptone only the blue pigment is found. This bacillus is usually a secondary infection, and is associated with staphylococci or streptococci, but it alone may be the cause of suppuration.

Colon bacillus, or Bacillus pyogenes fetidus, produces stinking pus. It is not to be considered the sole cause of foul-smelling pus, for a secondary saprophytic infection may cause any suppurative focus to have a putrefactive odor. Bacillus coli communis is found more frequently affecting tissues in the anal and perineal region, and with great frequency in peritoneal infections, especially those due to perforations of the appendix, which so often emit foul odor. Habitually within the gut, it is potent with harm once it gains admission to the peritoneal cavity.

Bacillus anthracis, the cause of malignant pustule, is one of the largest bacteria, and one of the earliest recognized by the microscope by Pollander in 1849, although its relation to the disease anthrax was not recognized for many years. It is prolific in spore formation, and, unlike tetanus bacillus, does not show increased width at the level of the spore. It grows in chains very much as streptococci, but the chains contain many more individual bacteria than the latter.

Bacillus mallei is a non-motile, aërobic, slowly growing germ (on culture-media). It is not known to be a spore producer, but possibly is.

Bacillus of malignant edema is a very large anaërobe, found under similar conditions to tetanus, and contaminating tetanus cultures more frequently than any other germ. It produces a spore centrally and is motile. Like anthrax, the bacilli grow end-on in chains of great length. This bacterium does not frequently affect man, although it often attacks the lower animals.

Bacillus aërogenes capsulatus is almost as large as anthrax, but does not habitually grow in chains, a very important distinctive characteristic, although at times they are seen in short chains, pairs, or clumps. In the tissues the bacillus is usually found to be distinctly encapsulated. It produces spores and is anaërobic. Like the Bacillus mallei and bacillus of malignant edema, it is not often encountered clinically, but should be recognized when it is.

Pfeiffer's bacillus, or *Bacillus influenzæ*, is the accepted cause of grip, and is found in the secretions from the mouth and the air-passages. It is the cause of the otitis media and meningitis complicating grip, and is found in certain acute and chronic respiratory lesions. It may cause pneumonia, and this is often followed by abscess of the lung. This bacillus is sometimes recoverable from the air-passages or mouths of healthy people.

Bacillus fusiformis is an anaërobic bacillus which produces a mouth, tonsillar, or throat lesion known as Vincent's angina. The bacillus is long, has pointed extremities, and is larger in its middle. Cultures of this micro-organism emit a foul odor. It is found also in noma, and is probably the cause of this condition.

- Bacteria
  - Saprophytic
  - Pathogenic
    - Cocci
      - Diplococci
      - Streptococci, several strains
      - Staphylococci
        - Aureus.
        - Citreus.
        - Albus.
    - Bacilli
      - Tetanus, Anthrax, Tuberculosis.
      - Colon, Typhosus, Pyocyaneus.
      - Mallei, Malignant edema, Aërogenes capsulatus.
      - Bacillus influenza and Bacillus fusiformis.

Atria of Infection.—The point of entrance of germs into the body is known as the atrium of infection, or simply the atrium. They may gain access to the tissues with or without injury to the tegument. When the latter occurs it is usually by the mucous membrane of the intestine, and here tubercle bacilli are the chief invaders. The various routes of infection are as follows:

(1) *Through wounds,* the most frequent source of general infections, which under ordinary circumstances are impotent unless the epithelium is broken. Fortunately so; otherwise continual invasion would be suffered. The size of the wound, its depth and subsequent behavior, may or may not be significant of the presence or the type of infection. Large wounds may be infected but little and heal kindly, and in small wounds even the slightest disruption of the cuticle may receive a large amount of virulent infection and result disastrously. Superficial atria are less, deep ones are more, favorable to anaërobic infections, but anaërobic infection cannot be excluded on account of the superficiality of the wound. Certain of the non-pyogenic bacteria may gain admission through a wound, and, though causing no perceptible interference with healing *per primam,* result fatally before or shortly after such healing.

(2) Through the *mucous membranes* of the air-passages micro-organisms are admitted into the tissues so as to produce disease. This is much less frequent, so far as the lining tissues of the lungs are concerned, than was formerly thought, although there can be no doubt of direct infection of their tissues. It is now established, however, that much of the pulmonary infection observed is secondary to infections from the alimentary tract. The same thing may follow cervical lymph-node infections. The tonsils, pharyngeal and faucial, are frequently affected by infective processes, especially in chronic hypertrophied conditions, by tubercle bacilli.

Secondary to these, the lymph-nodes, into which drainage from the primarily affected structure occurs, become affected, and after these remote or general infection may follow, dependent upon the virulence of the bacteria and the individual's resistance. The mucous membranes of the nose are often the site of ulcers, small wounds, or bruises, and of acute inflammatory processes, which reduce the local resistance to infection and render them, therefore, atria for various bacteria. So it will be referred to later that the so-called idiopathic facial erysipelas is due to entrance of streptococci through some concealed atrium in the upper air-passages.

(3) *The Alimentary Tract.*—From the lips to the external sphincter ani is one continuous flora of infection. There are certain species habitual in certain portions of the tract, as the colon bacillus in the lower gut; there are certain additional species constant in a few individuals, such as Klebs-Löffler bacilli or the diplococcus of pneumonia, and this tract is subject to entrance of any of the vast numbers of varieties of micro-organisms contaminating food and drink, and the great variety of unnecessary and unclean things introduced into the mouth as a diversion or as the result of habit. So it is evident that, unless tissue resistance were wonderful and eternally active, man must, of necessity, succumb to the microorganic world. The presence of particles of food between the teeth and around them, subject to decomposition in unclean mouths, increases the total number greatly; it converts the mouth into a very ideal culture-tube. So it becomes patent how necessary it is to cleanse the mouth thoroughly as a preliminary to anesthesia, since aspiration of such foul material certainly causes a goodly percentage, if not the majority, of postanesthetic pneumonias. This thorough cleansing of the mouth should be done by a competent dentist, and is imperative in cases which are to be subjected to gastric surgery.

Caries of the teeth is another source of infection; one, too, that should not be allowed to continue long; but among the lower classes, the indifferent, and the penurious it is so frequent as to demand especial emphasis. The same observation made on preparation of the mouth applies here. If, from financial straits, they cannot have permanent dental work done, they should at least have temporary fillings.

The mucous membrane of the intestine is no longer considered able to prevent the entrance of bacteria with the chyle, even though no abrasion be present. Tubercle bacilli fed to healthy individuals gain entrance to the tissues by this route, and many other organisms probably, but with less frequency.

It is possible to prevent a large amount of the mouth infection by cleanliness and carefulness as to the nature of the food used.

Cooking does much to prevent the entrance of pathogenic bacteria into the alimentary tract, as also the animal parasites, such as cysticercus and trichina. Most food is cooked, still enough uncooked food, with water and other fluids consumed, is used to keep up a continuous reinfection. These can be sterilized in the same way, as, indeed, is done voluntarily or by compulsion in the presence of grave epidemics so conveyed. There remains one item worth mention—the cook or waitress may, by handling food carelessly after cooking, infect it and convey disease that could not have been contracted from the raw article, or, by handling dishes, infect them so as to force the disease upon the user, even when every specious precaution has been taken. Thus carriers transmit disease.

(4) *The Genito-urinary Tract.*—Owing to the fact that infection may be introduced into the genito-urinary tract, and may ascend or descend, as the case may be, from one end of it to the other, attack the various follicles and channels opening into the chief passages, and affect surrounding tissues or become generalized, this is one of the chief locations of primary infections, which ultimately cause serious local or general lesions. The kidneys are among the first in eliminating bacteria from the body when they have gained entrance to the blood. Hence, whatever the nature of the infection, the whole tract below must be bathed in urine containing it, and may at any time be attacked. If there is obstruction to the flow of urine, or if residual urine be present and decomposition of this stagnant urine occur, infection is almost certain. Again, the distal end of the passage is subject to afflictions peculiar to itself, which, when they have once gained entrance, may stop short of nothing less than the whole tract, extending from urethra to the seminal vesicles or the testicles, or, in the female, from vagina to uterus, from uterus to tubes, from tubes to peritoneum. The urethra and vagina habitually contain micro-organisms derived from without, but they do not usually thrive well, since vaginal secretions are antiseptic and normal urine is sterile.

(5) *Placenta.*—It has long been known that placental transmission of disease from mother to fetus does occur. The most prominent example of this is found in maternal hereditary syphilis, an observation made hundreds of years before the advent of bacteriology. Other diseases, especially medical, are well known to be transmitted similarly; for example, the acute exanthemata, children being found with the eruption at birth or a shorter time thereafter than the period of incubation. Tuberculous children are also rarely found at delivery, and there is no reason for doubting that the bacilli may lie dormant in the infant for variable periods subsequently, and, when circumstances are favorable, assume

activity. This is likely a rare method of conveyance as compared with the usual external contagion.

Elimination of Bacteria.—The question naturally arises, What becomes of the bacteria which enter the body and produce disease, particularly if the patient recovers? Some of them are destroyed by the fluids and the cells of the tissues, others are isolated by the formation of cicatricial tissue encysting the infected focus and shutting off their opportunity to invade other structures, others are expelled from them by the organs of elimination and secretion. The site of the chief lesions determines, to some extent, the preponderance of the work of elimination on some one route; if the pathology is especially intra-intestinal, the majority will pass with the feces; if genito-urinary, then with the urine; this is simply an accident of the performance of normal function. If the bacteria are in the tissues remote from these passages or in the blood how are they eliminated? The answer may be brief, namely, by the excretory and some of the secretory organs. The urine, in many cases of general infection, demonstrably contains the causative bacteria, as may be shown by culture, inoculation, or microscopic examination, in cases where there is no infection and has been no instrumentation of the urinary passage. This is evinced, in a clinical way, from the large number of involved kidneys or their pelves in the course of general bacterial conditions; the same method of elimination likely occurs more often in localized processes than our knowledge would warrant us in claiming. Likewise, bacteria are recovered from the sweat of certain cases of general infection. The liver is another route of elimination, which, by pouring the bacteria out with the bile, ultimately throws them into the alimentary tract. Many are destroyed in the liver. At times bacteria are recoverable from the secretory glands, especially the parotid, and, in a few instances, they may be found in the milk.

Significance of Infection.—The term "infected" has a dual meaning, depending on the view-point assumed. In the literal sense, the view of the bacteriologist, any tissue containing bacteria is infected. Since it is probable that no wound is made, accidental or operative, into which a number of bacteria do not enter from the hands, from the tissue surfaces, from unclean objects coming into contact with it, such as clothing or dressings applied by the laity, or from particles of dust in the atmosphere; and further, since most wounds nowadays show no signs of infection, it is evident that the surgeon means something entirely different when he says a wound is not infected. It is demonstrated that in at least the majority of cases it is impossible to sterilize thoroughly the hands or the operative field, and known that in many instances the operator is compelled to work in a plainly infected field, yet without contamination of his wound. Absence of infection from this view-point is used in a relative sense, and means that either no bacteria are present, or, if they be present, are in quantities insufficient to produce inflammatory or other signs and symptoms and to interfere with healing by first intention. So the task of preparation of the hands and the field of operation is confessedly an incomplete work at its best; therefore, every effort must be used to approximate as nearly as possible an unattainable ideal. Infection, in this latter and usual sense, means that a dosage of bacteria sufficiently large to affect the tissues has been introduced. This dosage varies widely for different bacteria. Some of them the tissues have little or no power to overcome; fortunately they are rarely admitted. Another species may be admitted in considerable numbers, and be destroyed without the appearance of a blush of redness or a drop of pus. The degree of virulence or attenuation of the bacteria will determine whether a given organism in given quantities will produce infection. On the other hand, the result of the introduction of bacteria into a wound is determined by local and constitutional conditions present. The general resistance of the patient may be low, from loss of blood, from disease, from exhaustion, and he be thus liable to succumb to numbers, which, if he were normal, would be disposed of in a few hours, with no evidence of other than a sterile wound. Locally the blood-supply has much weight in determining the result. The face and mouth often heal *per primam*, even where no effort at cleanliness is made; their blood-supply is good, whereas the joints are very susceptible to small infections since they are less abundantly supplied. The anatomic factors are unavoidable, and must be accepted as they stand. Again, any action or negligence on the surgeon's part that favors reduction of tissue resistance is as culpable, though frequently not so patent, as actual neglect of aseptic technic. Reference has been made already to the removal of all blood-clots, the control of even slight hemorrhage, and the excision of devitalized tissues. These must be done, and drainage must be introduced, if necessary, to avoid uncontrollable accumulations of lymph or blood, although drainage in itself is not an unmixed good. Other things must not be done if the best results are to be expected. Non-absorbable suture and ligature material, with all due respect to the great surgeons who still use them, are so much foreign substance in the tissues, and may, months after healing, become the site of infection and result in abscess and sinus or fistula, and necessitate a second operation for their removal. It is the consensus of opinion that non-absorbable material is harmless in clean intra-abdominal work. Unnecessary traumatism to the tissues during operation, such as compression of large masses in clamps, tearing, mangling, or bruising, and the destruction of blood-vessels which an accurate knowledge of anatomy would not warrant, all favor the development of infection. The ligation of masses of tissue with the vessels, the use of unnecessary quantities of catgut, or ligatures and sutures of too large size, and the formation of unnecessarily large knots in buried sutures or ligatures, all accomplish the same end. Catgut becomes an excellent culture-medium when buried in the tissues, and the knots are often the only remains to be found in abscesses forming after healing is accomplished. Tying knots tightly with ungloved hands is likely to force from the follicles of the skin sufficient bacteria to cause infection. Sutures are applied for the purpose of approximating tissues, but must not constrict them. When tied tight enough to shut off the blood supply, they not only fail in their purpose of obtaining union, but cause the tissues to die, and offer the same conditions favorable to infection as if lifeless masses were left at the time of operation. The use of antiseptics is often a specious and harmful effort to destroy bacteria in wounds; they not only fail often to do so, but put *hors de combat* the only agents that can, and leave the wound surfaces crippled or dead, so that they can no longer resist even infinitestimal quantities of bacteria. This may all be summed up in a word—whatever reduces the vitality of the patient as a whole, or of the part concerned, favors the development of bacteria. Injections of pathogenic germs into the peritoneal cavity are taken care of by the powerful destructive and absorbent capacity of that membrane; the same dosage, introduced with a considerable quantity of water, produces fatal peritonitis, due to the consequent slower destruction and removal of bacteria.

Manner of Producing Disease.—The mechanical presence of bacteria, so far as it may have weight in the production of disease, may be discarded as negligible. If pathogenic bacteria should be so enormously abundant as to block a comparatively few capillaries, an unusual occurrence, even then the chief effect would be in a different direction. As bacteria grow and multiply, they produce and throw off certain toxic substances, which may be called excretions for want of a more definite understanding of them, and these excretions produce the symptoms growing out of an infection. These poisons are known as toxins, which are soluble, closely allied chemically to albumins, and very violent in their action on tissues. These poisons are liberated from the bacteria into the tissues or the culture-medium and remain after filtration of the medium. They are different for different bacteria, each pathogenic species producing its own peculiar toxin. Toxins are chemically unstable, being unable to resist higher temperatures than 80° C. and slowly decomposing at from 50° to 60° C. Certain bacteria produce toxins which have the power of disintegrating or dissolving red blood-cells (hemolysins). The toxins may act locally, producing no perceptible constitutional symptoms, or constitutionally, with few or no local signs, or they may act in both ways at the same time. The tetanus bacillus will produce slight if any local changes, and so act on the motor centers as to result in death in a few days or hours, besides having a hemolytic influence. There are contained within the bacterial cells poisons which are not thrown off from their bodies as the toxins are, and cannot become a part of the culture-media until they are disintegrated. They are not specific, as the toxins are, but are supposed to be identical in the various classes of bacteria, and are, for the most part, pyogenic. Hence, when an infection occurs the toxins act locally and generally, while the dead bacteria that disintegrate or are destroyed by leukocytes may cause general disturbance, as shown by the rise of temperature and local inflammatory or suppurative changes. The virulence of all toxins and endotoxins varies with different species of bacteria; one is so intensely virulent as to be influenced by no degree of resistance on the part of the tissues, and another so mild that severe reduction of normal resistance must be sustained before they can gain a footing; likewise in the same species the virulence varies widely; a strain of streptococci from a dangerously infected patient is almost certain to produce a virulent infection on gaining entrance to a new field. The same fact is a matter of common observation; one series of cases of typhoid will be mild, with a low mortality and few and mild complications; another epidemic violent in its mortality and complications.

Mixed Infections.—If a pure culture of bacteria gains entrance to the tissues it produces an infection, simple or single infection. If more than one species be present it is called a mixed infection. The bacteria first gaining entrance constitute the primary infection; the second admitted constitutes the secondary infection, and so on. Hence, a mixed infection may mean that two or more species were present at the beginning, or that one was present and subsequently another superadded. An infection occurring after all bacteria pass from the field is called reinfection. Mixed infections are, under certain circumstances, capable of infinitely greater harm than a single infection. The primary infection may be of no further consequence than to reduce the vitality sufficiently to allow a violent secondary infection to gain a footing and produce death. The primary infection may be aërobic, and an anaërobe superadded may thrive in the presence of the first infection, although it could not have found the field sufficiently oxygen free to produce disease otherwise. Tubercular infections are much more serious in symptomatology and outcome when secondary pyogenic infections are added. This is especially true if the secondary infection is streptococci. The same precautions must, therefore, be taken to prevent secondary infection being engrafted upon a primary as would be taken to prevent a primary infection.

Antagonistic Bacteria.—Of little practical therapeutic value as yet, it remains an interesting fact that certain bacteria are mutually antagonistic. Anthrax and erysipelas are perhaps the most notable examples. When both are present in an animal it stands a better chance to overcome them than when anthrax alone is present. However, either may gain the ascendancy and produce death. It is also known that certain bacteria will not grow on a medium on which another species has lived. Curative properties have been observed in infections, especially with streptococci. Sarcoma (which is not an infection) has, in a small percentage of cases, recovered after an attack of erysipelas, and the attempt has been made to treat sarcoma with sterilized cultures of streptococci, sold under the name of Coley's fluid. The favorable results have been comparatively few. Recently Schiotz has demonstrated that Klebs-Löffler bacilli disappear from the throat of carriers of diphtheria if a spray of living Staphylococcus aureus is persistently employed.

The Protective Powers of the Body.—The ubiquitous distribution of bacteria, the frequent contact of the body outside and inside with them, and the numerous wounds and other lesions that might serve as atria for the entrance of infection, have been studied, and force upon us the conviction that, without a very extensive resistance on the part of tissues, there would be constantly present in the body some form of infection, if indeed existence were at all possible.

Epithelial Protection.—The surface of the skin and mucous membrane is covered with epithelium which must act as a barrier to the entrance of bacteria into the subjacent tissues, if one considers the rarity of infection while the epithelium remains intact and its frequency when the epithelium is denuded or broken. These epithelial cells are not favorable pabulum for bacteria, and, although the hands may continually come in contact with virulent bacteria, infection is very rare. When it does occur it is because the follicles or glands of the skin serve as points of vantage, as has been shown by the production of furuncles by rubbing pure cultures of Staphylococcus aureus on the skin. Bacteria, therefore, may abound on the surface of the body or of the mucous membrane and multiply without limit in the contents of the alimentary tract with no resultant harm. That the epithelium is a barrier to the entrance of bacteria is sometimes spoken of as the law of Wyssokowickz. The mucous membrane of the intestine is not completely amenable to this law; it has been demonstrated that bacteria do enter with the chyme into the lacteals, and thence escape into the general circulation, even at a time remote from their passage through the wall of the gut.

The Law of Metschnikoff.—When bacteria gain entrance to the tissues their spread would again easily become universal unless they were interfered with. As soon as an insoluble foreign poisonous substance, animate or inanimate, gains admission to the submucous or subcutaneous tissues, large numbers of leukocytes gather in and around the field invaded, wall off and isolate that field, and begin their work of destruction. This is known as the law of Metschnikoff. This is a most efficient means of localizing infection, and does not fail, except when the bacteria spread so rapidly or are so numerous that the leukocytes cannot keep pace, or when they are so virulent that a negative chemotaxis is present, or when the wall of leukocytes is broken up by extraneous forces. It is, therefore, much more difficult for bacteria to produce disease in a healthy granulating wound than in a fresh one.

The Action of Lymph-nodes.—The fluids going centrad in the lymph-vessels frequently contain bacteria; this was shown above, in the entrance of bacteria through the intestinal mucous membrane, and occurs in the great majority of infections. The lymph-nodes are abundantly placed at the most likely portals, and serve as living filters to all the fluids passing. Arranged in series, few bacteria can escape them under normal conditions. When they become overloaded they are rescued by the leukocytes coming to their assistance, as elsewhere, or are sacrificed for the protection of the more essential tissues. In this way inflamed or suppurative lymph-nodes are produced.

Chemotaxis.—Living cells have the power of approaching and attacking foreign substances, animate or inanimate, which may intrude themselves into the tissues, or of rejecting them. This is known as chemotactic power, and the exercise of it is chemotaxis. If the cell (leukocyte) consumes the foreign body, the bacteria, chemotaxis is positive; if it refuses to do so, chemotaxis is negative. There is some capacity in the leukocytes especially, and in many other types of tissue cells less frequently, that enables them to perform this function of phagocytosis, positive chemotaxis, or to refuse to perform it, negative chemotaxis. The cause underlying chemotaxis is the toxicity of the bacteria; the greater their virulence, the less able the leukocytes are to attack them. By injecting virulent streptococci into the peritoneal cavity of animals, and subsequently examining the leukocytes found in the peritoneal fluid, it is learned that few or none of the white cells contain bacreria (negative chemotaxis); on the other hand, the injection of a saprophytic species, like Proteus vulgaris, shows many bacteria in each leukocyte (positive chemotaxis). This is known as Bordet's experiment.

It becomes plain, from the above, that this particular factor of tissue resistance will be increased if, in the first place, the number of leukocytes can be increased adequately to cope with the number of bacteria in a given infection; if, in the second place, they can be brought into the field of action in sufficient numbers; if, in the third place, such dealing with the tissues may be performed as to increase their positive chemotactic power, or, with the bacteria, as to reduce their repulsiveness to the phagocytes.

PROTECTIVE CHEMIC POWERS

The chemic protective powers of the tissues are manifold; of chief importance are alexins, agglutinins, antitoxins, and opsonins. They will be discussed in their order.

Alexins.—The names mycophylaxins and mycosozins are used synonymously. The body fluids, serum, lymph, and fluids of the tissues, as well as many of the secretions, contain substances which give them a definitely bactericidal or bacteriolytic power. These substances, called alexins, must not be associated with the ordinary chemic antiseptics. The power of the latter is largely universal in their application. The destructive powers of the body fluids are specific in that, when their ability to destroy a special bacterium has been exhausted, they may still have a like capacity for another. This power fluctuates from time to time, and may be reduced to a valueless minimum by exhaustive infections. They have the same activity toward blood-cells from another species that they have on bacteria, producing hemolysis or hemagglutination. The alexins are capable (their complements) of attacking dead tissues, making traumata favorable atria by exhaustion of bactericidal properties. They are the product of white blood-corpuscles, and may be increased locally on demand, either by natural means, as in cases of infection, or by artificial means, as in irritation and Bier's hyperemia. A high potency of blood-serum against a species of bacteria is not proof against their production of disease, an example of which is typhoid fever.

Agglutinins belong to the same category as the alexins, if, indeed, they be not different manifestations of the same or closely allied chemic agents. Their power consists in clumping bacteria or blood-cells and destruction of motile power in the former. They are used as a diagnostic means in Widal's test for typhoid, but have no present therapeutic value susceptible to our control.

Antitoxins.—This term conveys its own significance in a superficial way, but neither this nor any other of the chemic protective agencies of the tissues has been worked out with sufficient conclusiveness to cause all investigators to agree as to the nature and origin of the agents producing the results. It is settled in a practical way so that the therapeutic value of antitoxins may be understood. An antitoxin is an agent that has the power to neutralize a toxin, without any deleterious action on the bacteria which produced that toxin. It is a something capable of preventing toxins from acting on the tissues so as to produce disease. Toxins are the product, direct or indirect, of bacteria; direct, if the poisons are produced within the bacteria; indirect, if there is produced in the bacteria a substance which, on liberation, becomes chemically combined with certain tissue compounds so as to result in toxins. Therefore, whether the antitoxin combines with the toxins and takes away their toxicity, or whether it separates them into two non-toxic segments, or acts on the non-toxic products of the germ, and prevents its ultimate combination to produce toxins, is practically one thing to the physician who must cure disease. The antitoxins in common use are in the form of antitoxic sera, chiefly antidiphtheric serum, antitetanic serum, antistreptococcic serum, and Flexer's antimeningococcic serum (bacteriolytic rather than antitoxic). As the toxins are different for different infections, so there must be an antitoxin for every species of infection; no antitoxin has curative properties for other than the species by which it was produced. Antitoxins are developed in the tissues in a given infection. The quantity may be small or great, depending on the amount and virulence of the infecting agent and the ability of the tissues to react. It may be so great that the individual, if recovering, remains for a time at least more or less immune to reinfection. In other instances the infection seems only to render him more susceptible to reinfection. Antitoxic sera are derived by inoculating animals (horses, sheep, and cattle) with gradually increasing doses of pathogenic bacteria until no further reaction can be produced by dosage that should prove fatal. The serum is derived from the blood of the animals, sterilized at temperatures which will not affect the antitoxic properties, and placed in sealed sterile tubes. The dosage is measured in units, a unit being the amount required to immunize a 250-gm. guinea-pig against the minimum lethal dose of bacteria which would otherwise kill it in three or four days.

Ehrlich's Side-chain Theory.—The exact manner in which cells combine with food molecules, reaching them for the maintenance of their vitality and the performance of their function, is not known. Likewise, it has not been demonstrated how toxins act on the cells to produce their deleterious effect and pervert or destroy the functions of the cells affected. The theory of Ehrlich, known as the side-chain theory, proposes to explain, and does explain, with more satisfaction than any so far advanced, the phenomena taking place in the case of toxic action. It has, therefore, become widely accepted. While it may undergo alteration as further evidence is gathered concerning the real chemic structure of cells and their action on their environs, still it conveys in a tangible form the facts of the case. In order to maintain their normal status of nutrition all living cells must be capable of taking to themselves and appropriating certain food molecules from the blood, and they must be controlled in this activity by some centralized power. Ehrlich conceives the nucleus to be the central directing part of the cell; the cell must have certain unsatisfied points of valency which are ready to take to themselves the substances flowing in the blood; these points of valency are themselves capable of liberation from the cells and of entering the blood as very complex radicals; they are called side-chains, distinguishing them from the central functionating nucleus. These side-chains vary for different types of cells, so that one cell may appropriate one substance and another something wholly different; that is, they are selective. When toxins are dissolved in the blood the side-chains of the cells capable of combining with such toxins do so, and make the toxin molecule a part of the cell just as if it were a food molecule, and so that the nature of the cell is changed and a perverted function arises or symptoms of toxemia are produced. It must be understood that the toxin molecule must enter into the cell physically and there make its combination with the receptors, for so the side-chains are called. It must further be understood that this whole process is of purely a chemic nature, and that the toxin molecule becomes a part of the cell substance, and is often thereafter inseparable from it. When the receptors are all used up in a cell, it proceeds to produce more of them, even in excess of the demand, stimulated by the action of the toxin-receptor combination. These become liberated from the cell, pass out through the cell wall and into the blood, directly or indirectly, and there remain ready to become united with the specific toxin molecule which has caused their overproduction and liberation, but with no other. Antitoxins are the free receptors in the blood or serum ready to combine with toxin molecules. When combined, they behave as inert bodies, having completely neutralized the toxin molecules. Adami thinks that a single toxin molecule within a cell may serve to liberate many receptors, somewhat after the action of enzymes; his view is that the toxin molecule becomes attached to the receptor, which is then liberated from its combination with the cell; on liberation, the remaining receptors attached to the cell manifest greater affinity for the toxin molecule than the liberated receptor does; so these two latter are separated, the receptor passes out of the cell to serve as antitoxin, and a new combination of the toxin molecule with an attached receptor occurs and is liberated; then a new receptor-toxin dissociation follows as before, and so on indefinitely, limited only by the capacity and endurance of the cell. If the primary dose of the toxin be great, there will be early exhaustion of the cells, and disease and death will follow. If the primary dose of toxin be slight, there results insignificant cell destruction and relatively marked production of antitoxins. If the next dose of toxins be greater it will be tolerated, owing to the antitoxin present, and a new stimulus is added to antitoxin production. This may be repeated until the animal will no longer be disturbed by a dose which at the beginning would have proved fatal.

It has been shown above that each toxin provokes the production of its own antitoxin. One toxin calls its antitoxin forth from one group of cells and another toxin from another group. There are, therefore, different types of receptors liberated to become antitoxins in each specific infection. This is true even when the different toxins act on the same class of cells, as shown by the inability of any antitoxin to neutralize more than one specific toxin.

Opsonins.—Among the chief protective powers of the body or the tissues are opsonins. They are the most important, too, from a practical consideration, inasmuch as they have been shown capable of therapeutic application for a considerable number of bacterial species, while antitoxins are useful in a very limited number, though of the most positive value in these. It is a matter of general knowledge that there is such a thing as producing changes in an individual by bacterial invasion (disease), which render him less susceptible to the disease or wholly insusceptible. It has likewise long been known that by certain processes (vaccination) an individual may have temporary partial immunity, as seen in the universal provision against small-pox. The fact that a patient has had a disease recently and recovered from it, while it may not immunize him against it, still may insure reduced susceptibility for a time, as in typhoid fever. Antitoxins, agglutinins, and bacteriolysins are responsible for a share in these results, opsonins for a much greater share. To put the problem specifically, the fact that a patient has had and recovered from an infection, and is then more resistant to it than before, is of itself an assurance that some change has occurred in the tissues, probably the blood. If it can be determined exactly what this change is, how it affects such results, and how its capacity to produce such results is established, then it may become of use to the surgeon and the physician in combating and preventing disease.

The word opsonin means "I prepare food for." The significance of this name follows.

It has been taught for a long time that the leukocytes have the power to destroy invading foreign substances, among them bacteria. Under chemotaxis above it was shown that the ability of leukocytes (phagocytes) to attack bacteria varied from a voracious destruction (positive chemotaxis) to a flat refusal to do phagocytic work at all (negative chemotaxis). It was not known till the epoch-making work of Wright and Douglas that any other agents were especially concerned in this phagocytic process than the two, leukocyte and bacterium. Wright and Douglas made the following experiment: They put washed living leukocytes into a normal salt solution at blood temperature and added a definite number of bacteria, and found, after waiting for a time, that phagocytosis had taken place. The number of bacteria destroyed per leukocyte was noted. They then placed the same relative numbers of leukocytes and bacteria in blood-serum from a healthy body into the tube at blood temperature, and found that the number of bacteria destroyed per leukocyte was markedly increased, demonstrating that the phagocytic action was enhanced by the presence of the serum. The question then arose, Does the serum increase the vigor of the leukocytes or reduce the negative chemotactic properties of the bacteria, and render them more susceptible to attack and destruction? Bacteria were then washed, treated for a time with normal blood-serum, washed again, and placed into the normal salt solution with the leukocytes, with the same result that had occurred when both were placed directly into the serum, showing the power serum has of so acting on bacteria as to enable the phagocytes to destroy them all or in much greater numbers. Hence, the name opsonins is given to the unknown agents in the blood capable of this action. The experiments continued—observations were made of the blood of persons who had had a specific infection and recovered. The opsonic power was invariably increased to varying degrees in different individuals. Against any other species of bacteria it was not increased. So opsonins are specific, as antitoxins and all the other chemic protective agents of the tissues seem to be. The increase of opsonic power against staphylococcus infection has no influence over typhoid bacilli or streptococci, but for. staphylococci alone. The next question to arise was, Is this opsonic power amenable to control, can it be raised at will? The use of living bacteria, if they could be so attenuated as to be harmless, would accomplish it, but would be manifestly objectionable and subject to almost prohibitive limitations. By fractional sterilization all bacteria and spores of a culture can be killed without affecting the chemic nature of their poisons. Proof of sterility can be easily made by inoculation into small animals as a guarantee against human infection by hypodermic administration. This was done, and found to influence the opsonic power the same as when actual infection had taken place, and with an agent which, though it contained a definite quantity of bacterial poisons, was yet devoid of the capacity to produce infection at the site of injection. The opsonic power could now be controlled.

Vaccines.—The preparations of devitalized bacteria are known as vaccines, whatever the process of devitalization. They are estimated in dosage by the number of millions of dead bacteria they contain or represent per minim or per cubic centimeter. They can be prepared and kept, at cool temperature, sufficiently long to be used satisfactorily in the physician's office. How long they may be kept is not known; heat destroys their value as soon as the temperature reaches 80° C., and gradually if kept long above 50° C. The heat of a hypodermic syringe, just out of the sterilizer, will reduce or destroy the efficacy of small doses drawn into it.

Opsonic Index.—The opsonic power of the individual varies widely, hence a standard must be had by which measurements can be made. The standard varies with the bacteria; therefore, in a given case the index must be taken for every species concerned. The opsonic index creates a standard for each species; it is the ratio of the opsonic power of the given case to that of normal serum. To put it more tangibly, let the number of bacteria destroyed by each leukocyte be the numerator, and the number destroyed by each leukocyte in normal serum be the denominator, the quotient is the opsonic index of the case in hand. It may be easily concluded that the normal opsonic power of animals compelled to combat certain species of bacteria, as, for example, in the case of man and the staphylococci, would be greater than that toward a less frequent but equally virulent infection. The opsonic index cannot be accepted as the measure of the total antibacterial resistance, for, as has been shown, there are other protective agencies of the tissues; but it may be accepted as a fair representation of individual resistance in those cases of infection against the bacteria of which opsonins may be developed at all; there are certain of the pathogenic bacteria against which man shows no opsonic resistance. The opsonic index may be termed a fair measure of the protective power of the blood, since by far the great majority of bacterial species attacking the living tissues are overcome by phagocytic action in the main, and since this action is efficient for some types only when the bacteria have been so acted upon as to diminish their chemotactic resistance.

The opsonic index may be raised as the result of an infection which has been overcome; by the presence of a localized infection which, though continuing unhampered, constantly throws into the general circulation its poisons, in quantities insufficient to overwhelm the general resistance; by the injection of living bacteria too attenuated or in quantities insufficient to produce disease; by the injection of vaccines prepared from devitalized cultures of bacteria. The opsonic index may be lowered by the same agencies that raise it, if they be administered in too great dosage. When the opsonic index is raised or lowered by infection, the result is brought about by continuous absorption of infinitesimal quantities of bacterial products, or by the gradual destruction of bacteria; when it is raised or lowered artificially, it is done by the injection of definite doses of bacteria, living or dead, at stated intervals of several (three to ten) days. The result of such artificial alteration is a reduction of the index during the first few hours, up to twenty-four, known as the negative phase, followed by a rise of the index to and above what it was at the beginning of treatment, the positive phase. As soon as the positive phase has passed its maximum, but prior to its reaching the level observed at the beginning, the second dose is to be administered, and so on.

It is frequently true that the general opsonic index is high, while that of the fluids in the infected area is too low, by virtue of the fact that the poisons in the infected zone are so much more concentrated that they constantly reduce it, or that it is reduced from the fluids therein more rapidly than it can be replenished from the circulation, which is necessarily impaired by the reparative processes or by disturbances associated with the inflammation present.

The determination of adequate dosage of vaccines in raising the opsonic index can be made absolutely only by the repeated taking of indices, too difficult for the practitioner and too costly for the patient. By beginning on doses sufficiently small to be safe, and by gradually increasing the dosage at each subsequent injection, a very satisfactory method is established for practical administration of vaccines. The clinical course of the disease is to be kept under surveillance, so that if any untoward symptoms, as local increase of discharge, or inflammatory signs, or constitutional symptoms, as an increase of temperature, headache, malaise, muscular or nerve pains, aching of the bones or joints, should arise, they must be taken as a signal that the dose is too large, too frequent, or both. On the other hand, as long as the local and constitutional symptoms improve, the increase in dosage may be kept up, always with caution. Vaccines will remain an efficient, though in unskilled hands a dangerous, remedy until some definite measure of dosage and reaction can be given—so far a hopeless dream.

There are certain conditions in which vaccines are worthless or harmful. Vaccine therapy cannot be used in all cases of infection, even of those infections against which the blood can produce opsonins. As a broad statement, it may be said that the use of vaccines is worthless in those cases where the amount of bacterial poisons is so great as to exhaust the natural recuperative power; where there is so great a toxemia or bacteriemia that the addition of more of the same poisons could only result in the further reduction of resistance. Therefore, in septicemic and miliary infections it is reasonable to expect nothing from vaccines. In affections of certain structures, for example, tuberculosis of the adrenal glands (Addison's disease), vaccines are of harmful influence. In certain infections, again, where the febrile reaction is great, showing a marked toxemia, vaccines may be harmful; tuberculin cannot be ordinarily administered with satisfaction when the daily temperature reaches 100° F. or more, except under the most guarded supervision. Mixed infections, where it cannot be determined which bacterium is most detrimental, and where a mixed vaccine might be desirable, are not favorable cases, due probably to dispropriate dosage of the two or more vaccine elements, so that one index may be raised while another is lowered. The administration of mixed or polyvalent vaccines may, however, be attended with most brilliant results. If the maintenance of a lesion be reasonably due to a single organism, and if, with this eliminated, the tissues could dispose of the other, then the opsonic index should be raised against the former. One of the most notable examples of successful vaccine therapy is the almost unerring certainty with which typhoid fever can be prevented.

Vaccines may be either autogenous or heterogenous; the former term signifies that the vaccine is made from a culture derived from the infection which is to be treated by it, therefore, of the same strain of bacteria and the same virulence; the term "heterogenous vaccine" signifies that the vaccine is made from bacteria derived from some source outside the patient to be treated. Autogenous vaccines were thought to be better than heterogenous, but the expense of preparation, the difficulty of finding a competent bacteriologist close at hand, and the time requisite for such manufacture, render it necessary to use the commercial vaccines, and these are very satisfactory if manufactured by reliable houses. It is highly probable that autogenous vaccines are not superior to heterogenous except where the particular strain of germs is not known. Whether the heterogenous or the autogenous vaccines are used, the diagnosis must be made with unerring accuracy. There can otherwise come only harm and disrepute from their use. It is true that in some instances a slight improvement may result from the use of a vaccine from a different family, closely allied, of bacteria, but it is never so good as when the same bacteria are used and is often worthless. To illustrate, it is necessary not only to know that a given infection is tubercular, but to determine whether it is of the human, bovine, or avian type; then the vaccines must be human, bovine, or avian accordingly. A slight good may result from the use of either of the others, but it is by no means certain even to influence the disease beneficially.

Immunity.—The term "immunity" signifies that an animal cannot become infected by the bacteria in question. If such bacteria be introduced into the tissues, whether they are able to multiply for a time or not, they cannot produce disease. Immunity is relative (partial) or complete. A very excellent example of relative immunity is seen in the incomplete protection vaccination gives against small-pox. The immunized person may, after successful vaccination, develop small-pox; it is of a mild grade, and produces slight symptomatic disturbance, no pitting, and a very meager eruption.

Further, it is known that the immune animal may be used to confer immunity on others by using the serum or blood injected into the tissues or vessels of the one in which immunity is sought to be developed.

To understand immunization, it is perhaps better to begin with those cases coming under observation in which certain ordinary poisons are used until the user is said to have a "drug habit," and can consume harmlessly, even with gratifying physical and mental sensations, many times the average lethal dose of that drug. The more usual of these are morphin and cocain. Immunity against these is certainly developed; whether it is similar to the bacterial immunity is not known; arsenic and strychnin can also develop an immunity in man. These may not only cause no harm when the habit is once acquired, but a demand, a hunger for the drug, is created. Arsenic may be injected into a rabbit in dosage sufficient to produce death in forty-eight hours. If a few hours previously one-fifth of the fatal dose be injected, and then the fatal dose, it is without effect. Again, the serum from the rabbit so treated, when injected into a rabbit which received a fatal dose, counteracts the poison so that it recovers. This is perhaps the simplest type of immunity.

Immunization may similarly be developed against vegetable alkaloids, robin, ricin, crotin, and others, so that enormous multiples of the lethal dose will be tolerated without harm. The ferments and enzymes, too, injected in small doses, cause the elaboration of antienzymes and antiferments, so that tolerance to these ordinarily poisonous compounds is produced. Snake venom and other animal poisons act the same way, and, by prophylaxis, the individual may be immunized against the stings and bites of venomous serpents and poisonous insects.

The immunization concerning the physician in the most practical manner is that against the toxins of bacteria.

Immunity may be natural or acquired. Natural immunity is inherited, that is racial, accidental, or individual. In racial immunity the species cannot be affected by inoculations of the bacteria in question. For example, man is immune against hog-cholera and hogs against human cholera. The bacilli of bovine tuberculosis do not attack man with the same ease as human tubercle bacilli (relative racial immunity). This racial immunity is probably due more to the lack of adaptability of tissues as a culture-medium or a specially strong antibacterial resistance for the specific micro-organisms than to the presence of antibodies; it is known that the injection of serum from a naturally immune animal into one not immune will not confer immunity upon the animal so treated. Individual, or accidental, immunity—that apparent immunity sometimes seen in an individual belonging to a species almost universally susceptible to infection—is likely not so much an immunity as a result of a chain of circumstances. It is certainly not due to antibodies; besides, it is difficult to know the history of the individual so well as to be absolutely positive he has not had the disease in question in a mild form or that his mother did not suffer from it during gestation. It is likewise not susceptible of proof by inoculation except indirectly. There are now and then found individuals who, although associated intimately with measles, whooping-cough, small-pox, or other contagious diseases, have never developed the disease; so also, in spite of repeated careful vaccination, it is rarely found impossible to get a "take." These facts do not so much establish the correctness of the view that individual immunity is a true immunity as the difficulty of infection, although very active, taking hold of tissues under certain unknown conditions; for these cases that have resisted infection often may later develop the disease under apparently much less favorable circumstances. It is known that even virulent streptococcus infections would often refuse to grow when attempts were made to inoculate sarcomatous patients with them.

Acquired Immunity.—Immunity is acquired in one of two ways—first, the individual has the disease, antibodies are developed in the tissues, and he is no longer susceptible to such infection. The contagious diseases of childhood belong to this class. This is known as active acquired immunity. The development of active acquired immunity carries with it always the risk to the patient's life and the chance of complications and their subsequent ravages.

It subjects the patient to a frightful prognosis, as seen in the case of meningitis (meningococcus), diphtheria, and tetanus. Second, immunity may be produced artificially, without the risk of fatality or serious sequelæ. This is known as passive acquired immunity. Vaccination against small-pox is an example of it, produced by inoculation with an attenuated virus (whatever may be the nature of the cause of small-pox). Antidiphtheric serum injected not only immunizes against diphtheria, but, if used during the presence of the disease, is par excellence curative. Antitetanic serum has the same property of immunization even after infection has occurred, but has not the curative capacity of antidiphtheric serum. Each neutralizes free toxins in the tissues, and continues to do so as they are elaborated, until all its receptors are used up or toxins are no longer produced. Antitetanic serum does not seem to have the abilty to neutralize those toxins already combined with the receptors of the central nerve-cells; thus, it is not curative. Diphtheria antitoxin, on the other hand, in the presence of grave constitutional symptoms, may give relief very soon after its use, due to the fact that the free receptors are able to take up even the toxins already combined with the unseparated receptors.

CHAPTER II

ASEPSIS AND ANTISEPSIS

THE term "septic" is applied loosely to any tissue or object that has bacteria on or in it. The term "surgically clean" means the absence of bacterial contamination; septic, then, means surgically unclean and untrustworthy. Owing to the universal distribution of bacteria, everything, except living tissues not exposed to the outside world (subcutaneous and submucous tissues), is accepted and acted upon as being septic until rendered clean and sterile.

Asepsis means the attainment and maintenance of a condition of sterility; it means, in a word, the absence of living bacteria or spores. Asepsis is not always attainable, so the term has come to mean, in a loose way, the approximation of freedom from contamination. It has already been shown that it is practically impossible to be entirely rid of bacteria in any class of operative work. When the field has been so cleansed that, though insignificant contamination with bacteria must occur, it remains insufficient to produce infection, it is accepted as aseptic work, but provided only that adequate means have been exhausted to accomplish asepsis. The ability of the patient to overcome large numbers of bacteria introduced at the time of operation does not prove that the technic was aseptic. Contrariwise, the occasional appearance of infection in long series of cases shows conclusively that the best efforts are only proximal. What has, by a fortunate accident, turned out favorably in one case or one tissue, in another may end in death or in an embarrassing infection.

Antisepsis is the employment of means to procure asepsis. The agents used are antiseptics, although this term is restricted by usage to mean usually only chemic agents which destroy or devitalize bacteria.

The agents at command for obtaining asepsis (antiseptic agents) are three. Their relative values and limits of application will appear under the description of each.

Antiseptic Agents.—There are three fundamental methods of producing surgical sterility:

(1) Mechanical Method.
(2) Thermal Method.
(3) Chemic Method.

Mechanical Method of Producing Asepsis.—By the use of mechanical agents for sterilization is meant all those factors which may be used for the removal of bacteria from the object to be sterilized. No attempt is made by this means to devitalize or destroy bacteria. The surfaces are to be cleansed of them as of so much dirt. This is generally the most underestimated, and really the most important, part of sterilizing skin and mucous surfaces. All foreign material—blood, dried clots, grease, dirt, trash, hairs, rust, and such like—must be removed from the thing to be sterilized. This may be difficult, but failure to do so renders sterility impossible. The first step consists, then, in the removal of gross visible contaminating substances. The razor must be used unsparingly, as nothing is so sure of wound contamination as too narrow a field for work, surrounded by hair. Solvents are used to remove all grease or oil. Nothing conceals bacteria better or holds them faster. Sulphuric or acetic ether, alcohol, and benzene are always obtainable, and serve as well as any. The last is better for cleansing skin grimed and greasy, such as engineers present; the former two, however, possess the advantage of having additional chemic antiseptic properties not now under consideration. It may be accepted that the chief value of the three for present purposes is their solvent capacity.

The usual process of mechanical cleansing consists in the vigorous use of soap and water, applied with a brush or a piece of gauze. This is usually the first step, except when grease is abundant, or some other substance, such as tar, which does not yield easily; here the solvents are better applied at the beginning. The soap, brush, and water must be sterile, and the washing done in a sterile vessel, or preferably in running water. Green soap, tincture or solid, is the standard preparation. It should be kept in receptacles which will render contamination impossible. Any pure toilet soap answers the purpose remarkably well. Sapolio or any other sandy soap is useful on vessels, floors, etc. The water must be as warm as can be tolerated comfortably and the brush of medium stiffness; stiff enough to scrub well, soft enough not to cut the epithelium. The washing must be done systematically, covering the whole surface several times, and no minute spot should be allowed to escape. If a vessel is used, several changes of water should be made; if running water is used, it should flow constantly or frequently over the parts. Scrubbing should be done in at least two directions, to avoid the escape of any crease or crevice. All regions the brush or gauze cannot reach must be cleansed by some implement that will do so efficiently.

After the scrubbing, one of the solvents may well be used on the tissues. When this mechanical method is well employed, there remains little to be accomplished by the chemic. It should be regarded as the chief part of the process, and the chemic as subsidiary.

The mechanical method of cleansing is useful for the following purposes: cleansing the hands for aseptic work; preparing wounds, skin, and mucous surfaces for operative procedures; removal of the gross contamination from untensils, instruments, fabrics, furniture, floors, walls, and such like; to be brief, it is to be applied whenever possible on account of the nature of the object to be sterilized. It must be considered as the most fundamental and most essential step of aseptic work; when it can possibly be employed, no other method should be allowed to take its place. In other words, it is absolutely a requirement that every substance intended for chemic or thermal sterilization shall first be clean. An exception is found in those objects usually sterilized by the actual flame.

Thermal Method.—The most widely applied and the most satisfactory, the ideal means of accomplishing absolute asepsis is by the use of heat. It may be applied in the form of the flame, hot air, hot water, or steam. The first two are known as dry sterilization. The use of steam and boiling water are known as moist sterilization. These various means of sterilization by heat are used as comports best with the nature of the object to be sterilized, the time at our disposal, and convenience for applying the various methods. Few apparatus can withstand the actual flame; many substances are destroyed or ruined by the use of boiling water or steam; others by air sufficiently heated to be of value; yet other substances cannot be sterilized by heat under any conditions. So the selection of the mode of application of heat must be carefully done.

The use of fire, the actual flame, or of instruments brought to a red or a white heat (cautery) is an altogether sure method in the production of asepsis. Platinum loops are introduced into the flame of a Bunsen burner, and, as soon as they become red or white, are sterile. Platinum vessels and vessels of earthenware, non-tempered and non-plated metals may be sterilized the same way. Metals which oxidize or tarnish easily, and those whose melting-points are not high, are immediately or early destroyed by such a process. Necrotic masses of tissues, infected ulcers, virulent specific inflammatory areas of small volume, phagedenic processes, and infected surfaces of organs about to be removed, which, by accidental contact, may produce contamination of a structure favorable to infection, are in a practical way sterilized by red-hot instruments as curative or prophylactic treatment in the hands of the surgeon. These cauteries may be heated by an internal automatic flame, by being placed in embers, a Bunsen flame, or by electricity. They are known as actual cautery; the first and the last are the most used and the most convenient; the second is not to be forgotten in case of emergency. It may be accepted that as soon as a tissue is

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charred it is sterilized; it must never be forgotten that immediately adjacent to the eschar abundant bacteria may pass unscathed, and be stimulated to higher activity and meet with less resistance, owing to the damage done the surrounding living tissue by the heat and the ready pabulum afforded by that destroyed but not removed.

Boiling Water.—In efficiency, boiling water stands next to the actual flame; it is also next in the time required for producing sterility. Boiling cannot be considered an instantaneous destroyer of bacteria and spores, so that by simply dipping objects into the vessel and removing them or pouring boiling water over them as they lie in the tray must be unsafe practice and should never be trusted. That it requires time in each of the practical methods of sterilizing to destroy bacterial life is a most essential consideration; none of them are or can be instantaneous in their action. Boiling water, in contact with pathogenic bacteria, destroys them in less than ten or fifteen minutes as a rule; if the objects to be sterilized are not clean, then the water may fail to reach through the grease, rust, dirt, or blood-clot, and come into contact with the bacteria; they are thus subjected to dry heat of 212° F. for the period of ten or fifteen minutes, which is inadequate. Spores are more resistant to the action of boiling water than bacteria are; some of them resisting its action for longer periods than fifteen minutes. It may best be put thus: Clean mechanically before boiling; boil at least ten minutes, preferably fifteen. The limitations of boiling water for sterilization are those imposed by the fact that much of the surgeon's equipment cannot be used when wet, and that tempered instruments may be damaged by frequent subjection to the process. All that can be boiled should be. It is the safest, the easiest, and the shortest means at hand.

Steam Sterilization.—Sterilization may be thoroughly accomplished by means of steam or boiling water. Most of the work of sterilization is thus accomplished, and the statement is fairly accurate, with such exceptions as are manifest, that what cannot conveniently be sterilized with one may be sterilized with the other. Steam sterilization is done under atmospheric pressure, or by higher pressure, accomplished by allowing its entrance into an air-tight chamber containing the objects to be sterilized. In the former case the steam is passed through a chamber with a relatively small outlet; in the latter, it is not allowed to escape until sterilization is complete. The time required should never be less than one hour for open steam sterilization; anything short of forty-five minutes must be considered positively unsafe; unless the packages are loose enough, and so prepared as to allow easy access of the live steam, the attempt will fail, since such a process is no more than an exposure of the fabrics to air heated to a point short of 212° F. The high-pressure steam sterilization, by which is usually meant a pressure of fifteen to thirty pounds to the square inch and a temperature of 250° to 300° F., requires thirty to forty minutes to sterilize, but it is customary in hospital practice to expose dressings, sheets, etc., for one hour. Care must be taken with all high-pressure sterilizers to allow all air to escape after filling the sterilizer, otherwise no sterilization. Whether low-pressure or high-pressure steam is used, the sterilizer must not be packed so tightly that easy circulation of the steam cannot occur. This mistake is sometimes made. The steam must come and remain in contact with every part of the dressings and vessels, and tight rolling or close packing militates against this. The temperature of the live-steam sterilizer chamber should be brought up for a few minutes before turning in the steam, so as to prevent condensation in the packages. After sterilization, the steam may be shut off and any excess of moisture driven off by hot air.

Hot-air sterilization is of no practical value to the surgeon, as he has no need for it. It is slow, difficult, and needless.

Fractional Sterilization, Pasteurization.—Many substances are so unstable as to be unable to withstand the heat necessary to destroy bacteria. The antitoxic sera, bacterial poisons, or bacteria used in the manufacture of vaccines and many other substances, such as certain of the culture-media, are chemically changed by boiling or by steam sterilization. Hence, they are submitted to temperatures short of boiling, 70° C., for thirty minutes to one hour, on the next day the same process is repeated, and again on the third or some subsequent day. Likewise boiling, as was shown above, may fail to kill spores, but does kill bacteria; after sufficient boiling, the fluid is set aside, and boiled again on the second and the third days. This allows the spores present to develop into bacteria, if they will, and enables us completely to destroy both. Subsequently to the fractional, or intermittent, sterilization, cultures or inoculations are made from the fluid sterilized. If a series of these experiments prove negative, the sterilization is accepted as complete; if one experiment is positive, the whole procedure must be repeated.

Chemic Sterilization.—This means of producing asepsis, like the thermal agents, has as its object the devitalization or the destruction of bacteria and spores. They are relied on only when heat sterilization is inconvenient or impracticable. In order to be effective *the chemic agents, antiseptics, must come in contact with bacteria, and remain in contact long enough to suspend their vital function or to alter their chemistry irreparably.* This may be simply a suspension of vitality. It has been shown that bichlorid of mercury may act on spores (anthrax) and prevent their development, yet when it is precipitated from them by the use of ammonium sulphid they are again capable of growth. Many chemicals are almost instantly deadly to all classes of bacteria, but they, at the same time, destroy the tissues, the field of greatest usefulness for this class of antiseptics. So the problem is to select a chemic antiseptic which is harmless to the tissues when applied sufficiently long and sufficiently strong to produce asepsis. It is well to know that no chemic antiseptic possessed of such requirements is instantly destructive of bacteria; the time of exposure cannot be eliminated; it varies for different agents and different strengths of solution. The effect of chemic antisepsis is always lost on all bacteria hidden away in crevices, crypts, or glands, or covered by grease, dirt, or blood; they do not reach such bacteria and cannot devitalize them. Any beneficial application of antiseptics presupposes the most scrupulous mechanical cleansing. The presence of tubercle bacilli in undried sputum is uninfluenced by immersing it in a 1 : 2000 bichlorid of mercury solution for twenty-four hours, but a solution of 1 : 5000 destroys the bacilli in dried sputum in the same time. This is due to the protection afforded the bacilli by the undried sputum from contact with the mercury. Antiseptic solutions having oxidizing powers, such as permanganate of potash, are exhausted early when placed in contact with substances readily oxidized and leave the bacteria unhurt. So also any antiseptic capable of combination with other substances associated with bacteria must be continually replenished or fail of its purpose.

It is feasible to take up only the more important antiseptics and those in common use in detail. The strength, minimum time limit, and the micro-organisms on which they have been tried out, as well as other important associate facts, will be given. This list may be accepted as covering the more important antiseptics, and from it the reader may choose what he finds the most acceptable for his purpose. The antiseptic habitually used by one surgeon with impunity may be so irritating to another's skin, even when casually employed, as to forbid his use of it at all. Again, the hands of one are ideal for surgical work, readily cleansed with soap and water, and leaving little to be done by antiseptics, while no amount of washing or possible antiseptics will render another pair of hands surgically clean.

Bichlorid of mercury is perhaps the most universally trusted antiseptic. It is used in aqueous solutions varying from 1: 2000 to 1 : 10,000, according to the purpose. A solution of 1 : 1000 destroys anthrax spores in a few minutes, and of 1 : 10,000 in two hours. If any agent, such as ammonium sulphid, be used to neutralize the effect of bichlorid of mercury on anthrax spores, it is found that the time required for the 1 : 1000 solution to kill them is one hour. The presence of albumin demands a much stronger solution and a longer time to destroy bacteria. Staphylococcus aureus is not always, though usually, destroyed by five minutes' use of a 1 : 1000 solution. Since staphylococci are among the most common pyogenic bacteria, and since a 1 : 1000 solution fails to kill them at times in five minutes, it may be accepted as a fact that the use of the standard 1 : 2000 solution cannot be expected to render surfaces aseptic by even a five minutes' exposure; less than this will only inhibit them, and simple immersion of the hands and immediate removal from the solution is of little more service than a similar application of sterile water.

The efficiency of mercuric chlorid is materially increased, and its combination with albumin is obviated by the addition of a mineral acid, such as hydrochloric, or of sodium or ammonium chlorid. Solutions of bichlorid of mercury in alcohol are more effective than aqueous solutions, due to the antiseptic and solvent action of alcohol.

Bichlorid of mercury, coming in contact with raw surfaces or granulating wounds, if of antiseptic strength, is deleterious in its action on the tissues, and leaves the field with poorer resistance to bacteria than if only sterile water or salt solution had been used.

Bichlorid of mercury is very toxic, and may be absorbed in sufficient quantity to produce death when used on raw surfaces or mucous membranes. It is not to be injected into the bowel or bladder and allowed to remain; even if sufficient quantities should not be absorbed it will act as a severe irritant to all mucous surfaces. It corrodes all metallic surfaces and dulls cutting instruments. Used about private homes, instructions should invariably be given to dispose of the solution in such a way as to prevent poisoning of children or animals.

Harrington's Solution.—After a long series of experiments with antiseptics, Harrington found that all of the agents used as antiseptics must be used in greater strength than the tegumentary surfaces will tolerate, or that the exposure must be impracticably long. He then set about to increase efficiency and to reduce the time of exposure to the shortest possible, without, at the same time, producing deleterious effects on the skin. Doubtless there are skins that will not tolerate Harrington's solution; if the skin will tolerate it, it is the most rapid practical antiseptic known. The formula is as follows:

Bichlorid of mercury	0.8 gm.
Hydrochloric acid	60. c.c.
Ethyl alcohol, 95 per cent	640. c.c.
Water, q. s.	1000. c.c.

This solution kills pyogenic bacteria on silk threads suspended in it ten seconds. The time of application to skin surfaces should be from thirty to sixty seconds, unless one finds that in one's own case the skin will tolerate a longer application. With this, as with other antiseptics, the fact must be borne in mind that sterilization of skin surfaces is only an approach to asepsis. After use of the above mixture cultures have occasionally shown positive. Harrington's solution, used on wound surfaces, is very destructive to tissue. It coagulates the blood in the open mouths of vessels and seals the lymphatics, having the same effect as the cautery in preventing the dispersion of bacteria through new atria opened by the operation.

Biniodid of Mercury.—Like mercuric chlorid, this is a powerful antiseptic, although it is used with less frequency; perhaps this is due to its greater cost. It is less irritating and less likely to precipitate with albuminous solutions, less toxic, though sufficiently so to be guarded against being used in such manner as to admit of too great absorption. It does not corrode metals so readily as bichlorid does, nor dull cutting instruments. Alcoholic solutions of biniodid of mercury, one part in 500 to 1000 parts of 70 per cent. grain alcohol, is the best means of using this drug, as it combines the antiseptic properties of the two agents. It may be used in aqueous solution varying in strength from 1 : 500 to 1 : 2000. Owing to its insolubility in water sodium iodid or potassium iodid must be added, in the ratio of 10 parts of the latter to 1 of the mercuric iodid. It is claimed by its advocates to be more antiseptic than bichlorid.

Sublamin.—A combination of mercuric sulphate, 3 parts with 8 parts of ethylene-diamin, is used in 1 : 500 to 1 : 1000 aqueous solutions for sterilization of the skin and instruments; it does not corrode metals, and stands near bichlorid of mercury in antiseptic power.

Carbolic Acid.—This drug is of interest from an historical standpoint, as it was used by Lister as the antiseptic in the first attempts at aseptic work, by spraying solutions into the atmosphere and over the wound, the surgeon, and the assistants. It ranks among the very best, if not the best, unmixed antiseptics to-day. Only its toxic and irritative properties to the tissues prevent a wider employment of it. Carbolic acid leaves the skin harsh and dry, and produces a numbness or anesthetic effect on the sensory nerve-endings very objectionable to the surgeon; used frequently, it damages the skin so that it can scarcely be sterilized. If solutions of carbolic acid are used on cutaneous or mucous surfaces they should be washed with alcohol immediately to neutralize its irritant and escharotic action.

In 5 per cent. aqueous solutions carbolic acid kills staphylococci in from two to five minutes; 2½ per cent. solutions require from four to ten minutes.

A very valuable field for the use of carbolic acid is found in the sterilization of sharp instruments when it is not desired to boil them. Here may be used the 95 per cent. acid in which the instruments are submerged for a few minutes. The receptacle should be so made that the fluid may be easily poured off; alcohol is then poured over the instruments, and they are ready for use. Where antiseptic and slight escharotic properties are both desired carbolic acid is the agent usually employed, such as swabbing out chronic infected cavities or protecting newly wounded surfaces from the contamination received at the time of injury.

Owing to the cheapness of crude carbolic acid it is conveniently used in the sterilization of excreta and clothing or bed linen contaminated by bacteria.

The fact that carbolic acid occasionally causes gangrene by its action on the tissues has caused many surgeons to be leery of its continued use, either for themselves or for their patients, especially such uses as the prolonged application, even in 5 per cent. strength. Not only so, the solutions of this drug are more likely to be absorbed and produce renal and constitutional symptoms than the pure form. In the rare cases where the pure drug is used the dosage must be guarded to prevent sinister results.

Cresol and *tricresol* are derived by fractional distillation of crude carbolic acid—the three forms are orthocresol, metacresol, paracresol. Tricresol is a mixture of the three. They may be used, just as carbolic acid, in the same strength with about the same or a slightly greater efficiency, and with less toxic and irritant effects. Hammer claims that 1 part of cresol in 200 has antiseptic properties equal to a 2 or 3 per cent. solution of carbolic acid; others have found its antiseptic action about equal to that of carbolic acid.

Lysol is a saponified preparation, containing, it is claimed, about 50 per cent. cresol. It is pleasant, moderately irritative, and efficient. Five per cent. solutions of lysol equal, in killing power, that of the same strength of carbolic acid. In weaker solutions it is less efficient than the latter. An advantage possessed by lysol is that it combines with its antiseptic property that of serving as a soap. It may be used in 5 per cent. strength for sterilizing the skin; however, even 1 per cent. solutions may cause severe burning of the mucous membrane, but no inflammatory or ulcerative action.

Creolin is saponified coal-tar creosote, and is efficient and safe in 1 to 5 per cent. solutions.

Potassium permanganate, used in a saturated solution, produces death to staphylococci in fifteen minutes. It is more antiseptic in the absence of organic matter. This preparation is used extensively for sterilizing the hands; the stain is removed by applying a solution of oxalic acid, which has little antiseptic effect. Potassium permanganate in weak solutions, such as may be used in urethral and vaginal injections, has an inhibitive action if long applied, but no destructive effect. Hence they are worth little more than a salt solution, except for deodorization.

Alcohol is antiseptic to a slight degree—70 per cent. strength is more antiseptic than stronger or weaker preparations; 50 per cent. alcohol is more antiseptic than 95 per cent., and should be used by preference for the tegumentary surfaces. Many bacteria are uninfluenced by forty-eight hours' application of alcohol, while others, among them tubercle bacilli, are destroyed in five to ten minutes. It cannot be accepted as a thoroughly reliable antiseptic. Its antiseptic value is much enhanced by its power of dissolving fats and oils; it is in this way that it liberates bacteria held by oil remaining on the surface after scrubbing. Owing to this fact, it is a better vehicle for such antiseptics as bichlorid of mercury and lysol than water is.

Ether has little antiseptic power. Anthrax spores, immersed in ether more than a week, develop readily on their media; a month's exposure is said to destroy their vitality. The importance of ether is that of dissolving oils and cleansing in a mechanical way; it cannot be trusted to exert any valuable antiseptic influence in the brief period of application ordinarily employed.

Hydrogen peroxid, full strength, is deadly to staphylococci in five minutes. Its expensiveness renders it of little usefulness for extensive work, although it is employed in antisepticizing wounds recently made.

Iodin has an antiseptic value of practical importance. It can be used in weak solutions, but is of little service. Its most important use is in the form of the tincture, applied directly to the skin surface after mechanical cleansing has been done and the skin thoroughly dried. It is of special value in the sterilization of emergency cases, such as penetrating wounds of the abdomen. It is applied as soon as the mechanical cleansing is finished and left on the surface during operation. The clinical results warrant the statement that it ranks among the best for such cases. Iodin has in the last few years been demonstrated to be one of the safest and most reliable antiseptics, as was first demonstrated by Grossich. It is efficacious in both emergency and routine work. In emergency cases the skin is dry shaved, and, if scrubbing must be done, either alcohol or benzene must be used. *Water on the surface immediately prior* *to the application of iodin is absolutely contraindicated.* The anesthetic is begun, and, as the patient approaches surgical anesthesia, the iodin solution is swabbed over the entire field of operation and the surface rubbed and kept moist with the saturated sponge for three or four minutes. It is then allowed to dry, and the surgeon may safely proceed. This method is the very best in the treatment of accidental wounds; the blood and clots are removed by dry, sterile swabs, and the iodin applied to the entire raw surface. If such treatment is done in a reasonable time pus will rarely be seen.

When there is time for deliberate preparation it is wise to do the dry shaving three hours before operation, and paint the surface with a 1 to 3 per cent. solution of iodin. This is allowed to dry and a sterile towel is applied. When anesthesia is complete, or just before, the second application of 3 per cent. tincture is used.

There is considerable difference in the practice of the various surgeons using the Grossich method or modifications of it. Some use alcoholic solutions, which I can vouchsafe are eminently satisfactory; others, including Grossich himself, use iodin dissolved in benzene. There is no objection to employing the pure tincture of iodin, except that it irritates the skin and may cause great distress unless the iodin is washed away with alcohol when the operation is finished. This is a good practice even when the weaker solutions are employed. In abdominal work the skin surface should always be protected with pads or towels if the Grossich method is employed, for it has been found that postoperative adhesions are much more frequent if the peritoneum is allowed to touch the iodized surfaces.

Natural Means of Sterilization.—Aside from the internal agencies combating bacteria present in the tissues, it has been shown that the secretions are to some degree antiseptic. This has been mentioned casually with reference to the latter. In cases of virulent infection it is often necessary to provide adequate escape for the bladder contents, and allow physiologic processes to accomplish a sterilization of the lining and of the deeper tissues of the genito-urinary tract, before undertaking a grave surgical procedure. So it is in cases of inflammation of the gall-bladder, of the pelvis, sometimes of the vermiform appendix. When the work of sterilization is admittedly incomplete, the infection is often so restricted or so attenuated as to render the field susceptible of safe work. So, too, especially in the stomach, duodenum, and upper end of the jejunum. The sterilization of the stomach cannot be done by antiseptics. Deprivation of food is the prerequisite condition; in thirty-six hours the contents of the stomach will show few or no bacteria, and work safe from infection from this source may be undertaken; a diet of sterilized food and drink, frequent light brushing of the teeth, rinsing the mouth assiduously immediately after meals, leaves the stomach with few bacteria as soon as emptied, and shortly (six to twelve hours) thereafter no bacteria are to be found except in those cases where they were abundant from disease or from inability of the stomach to empty its contents through a pyloric obstruction.

Sterilization of the Hands.—Preventive measures should be practised scrupulously and persistently until it becomes a matter of habit to avoid everything that can contaminate the hands or make them a favorable harbinger for bacteria. Allowing pus or other infective products to come in contact with the hands is always a double menace, first to one's self, since a slight abrasion or a subsequent wound may admit the bacteria to the tissues; second, to patients on whom operations are to be done subsequently, the importance of which can be seen if we remember that it is admittedly impossible in every instance to sterilize the skin. So important is this second item that direct contact of the hands with especially virulent infections should render the operator unfit for service for at least twenty-four hours, or until he has had opportunity to change all clothing and bathe again and again. He must put himself under voluntary quarantine until he can safely be trusted in the peritoneal cavity. The examination of the rectum and the vagina should be made with gloved hands, as any physician will gladly admit if he has had much of such work to do. Besides the safety, there is considerable comfort in knowing that it is unnecessary to contaminate one's self with what is universally recognized as filth. All dressings of septic wounds, should they be made by the surgeon, must be done without contamination of the hands. The habit of scratching, expecially the head or any part of one's body, must be discarded, for it necessarily accumulates more or less septic material under the nails, from whence it is most difficult to remove. Boring and picking at the nose serves the same end and in a more certain way, and cannot be tolerated.

As the hands must not be polluted, so they must not be permitted to come to such a state that they will unnaturally or unduly harbor filth and bacteria. The skin of many is so rough, and so subject to accident or disease, that this alone renders such a one unfit for surgical work. If chapping occurs easily and cannot be prevented, or eczema is present on the hands, they are unfit for surgical work. The hands must not be allowed to do rough work or handle grease and dirt; they become hard and rough, and, besides being unclean and uncleanable, they lose their delicate sense of touch. Abrasions and other wounds of the skin are ever a menace; they may seem not to be infected, but it would be difficult to prove that no pathogenic bacteria may escape from such a point during operation. Hence, protection must be afforded to the hands from direct pollution and from conditions which could favor such. The hands of the physician and, above all, of the surgeon must be considered sacred, for out of them are the issues of life and death.

The first step in the preparation of the surgeon's hands for operation should be getting rid of all clothing that will possibly touch the parts after asepsis is established. Further instruction will be given later on this point. Inspect both hands and forearms, remove all hangnails, and put the free margin of the nails and their base in prime condition. Remove all rough or uneven surfaces, but do nothing capable of roughening any part of the nails or the subungual spaces. The second step is washing the hands with brush or gauze pads, soap and water. The brush must not cut or lacerate the flesh. Green soap is the standard, but is by no means the only available one. Any soap capable of cleansing the skin without irritating it serves the purpose well. The water must be clean and should be sterile. If possible, running water is to be preferred; in default of running water, several changes should be made in the basin, which must be cleansed at the beginning and at each subsequent change of water.

The washing process requires variable periods of time, depending on the condition of the hands and the skill and understanding of the performer. Not less than ten or fifteen minutes should be trusted by the beginner, or by any one knowing of especial contamination of the hands. It can be done satisfactorily only when done systematically. Each finger is to be washed and the surfaces between adjacent fingers successively. The sides, the backs, the palms of the hands are to have their turn. Simply rubbing back and forth is not enough; they must be washed up and down and crosswise, until there is no chance of removable bacteria being left. The nails require the most important attention; on their dorsal surface the brush should be moved vigorously in transverse motion, then vertically, making certain that it reaches the depth of each lateral groove; then transversely in the subungual space. The beginner should follow some definite order of washing the hands till it becomes habitual.

After such washing, the nails should be gone over again and recleaned with a blunt metal or wooden cleaner until they are satisfactory; this can be done better if the hands are dried. Follow with a short rewashing and rinsing all soap from the surface with sterile water before using antiseptics; this is imperative if the antiseptic contains bichlorid of mercury.

In preparing the hands for operative work, it must be understood that the term "hands" embraces the upper extremity from the finger-tips to the elbows or above them.

After washing, if it has been done as recommended above, there will remain little to be done by chemicals. It is necessary to complete the work. It cannot be controverted, however, that of the two, washing is the more important, and, if either were to be preferred without the other, soap and brush and water would be the choice of most surgeons.

Whatever antiseptic may be chosen, it is well to precede its use by a careful rubbing of the hands and forearms with gauze saturated with 70 per cent. alcohol.

Below are several methods, any of which will give satisfactory results:

(1) Wash.

(2) Soak in bichlorid of mercury solution (1 : 2000) five to ten minutes.

(3) Rinse with sterile water.

If used frequently this method puts many hands in bad condition, as witness the hands of interns and nurses. It is worse, of course, if No. 3 is omitted.

(1) Wash.

(2) Scrub with alcohol (70 per cent.) and gauze.

(3) Soak five to ten minutes in bichlorid solution (1 : 2000).

(4) Rinse with alcohol.

This injures the skin little or none, unless it is very susceptible, and is one of the most satisfactory methods.

(1) Wash.

(2) Soak in saturated solution of permanganate of potash until the skin is thoroughly brown.

(3) Soak in saturated solution of oxalic acid till stains are removed.

(4) Soak in bichlorid of mercury five minutes.

(5) Rinse with water or alcohol.

This is objectionable to many because of the stinging effect of the permanganate and oxalic acid and the time required.

(1) Wash.

(2) Soak in Harrington's solution not less than thirty seconds nor more than two minutes, depending on individual tolerance.

(3) Rinse with water or alcohol.

If Harrington's solution can be tolerated by the skin for one minute this is perhaps the best known method.

(1) Wash.

(2) Scrub with alcohol (70 per cent.).

(3) Soak with carbolic acid solution (aqueous), 2½ per cent., for four or five minutes.

(4) Soak in alcohol till effects of acid are gone.

The last is perhaps the most dangerous method of the group, on account of the harmful action of carbolic acid on the skin and its tendency to produce gangrene. The above is rendered much more pleasant and safer, and not diminished in efficiency, by substituting lysol for carbolic acid.

Numerous other combinations may be worked out and are in actual service. The group given serves to illustrate the processes in vogue.

Sterilization of the Operative Field.—Because of the fact that the field of operation must be prepared for a single time, in a very small percentage of cases oftener than one time, the procedure may be carried to an extent more extreme than in sterilization of the hands of the operator. The first fact to impress is this—the field prepared should be large enough, so large an area, indeed, as will not only secure against infection of the wound in case of an ordinary incision, but such that even the extreme exigencies possible may not demand delay of work in preparation of a new field. Take an illustration: In appendectomy a small sterile area in the right iliac region would give fair results in the majority of cases. There would result a certain percentage of infection of the wound from unavoidable contact with the unclean surrounding border so nearby from slipping of the sheets and towels, and contact with hands or instruments. In a word, it is a risky procedure in the safest cases. In many cases it becomes necessary, from operative findings, to enlarge the incision far beyond the limits contemplated in the beginning, or to make a second incision toward the front, at times even in the loin. Too wide an area is rarely prepared, too narrow often. The nurse doing preparation must ask herself, not what the average case requires, but to what limit might extreme conditions require the surgeon to go, and act accordingly.

The patient, first, should have a general bath with soap and water, except in minor cases—it is better in these; then clean linen must be donned. This should be done on or soon after admission. If several days are required in hospital before operation the bath should be repeated at least once daily. Some hours prior to operation all hairs should be shaved from the operative field by a skilful hand and with a sharp razor. The skin must not be abraded. The surface is to be washed with soap and water, using a brush or gauze. The same precaution obtains here as in washing the hands. When this washing is finished the skin is to be washed off thoroughly with a fat-solvent, alcohol, sulphuric, or acetic ether or benzene. Then the antiseptic is applied, and must remain in contact with the skin or be constantly repeated for a longer time than the maximum required to kill pyogenic bacteria. Following this a dry sterile dressing may be applied snugly until the patient is moved to the operating table, when the whole may be repeated, or the surface may simply be wiped off firmly with 70 per cent. alcohol on gauze.

Manifestly, the presence of an inflammatory or suppurative process in the skin near the site of incision jeopardizes any effort at asepsis, and, unless the operation is imperative, it should be postponed until such process subsides. If it is imperative, then it may be dealt with as the case requires; it must be treated with the ordinary antiseptic measures. Any open, discharging spots may be cleaned off and cauterized with carbolic acid or iodin, or the actual cautery may be applied, or the whole surface may be painted with a solution of celloidin in acetone, which, when it dries, leaves an impervious membranous covering over the whole field. The incision is to be made through this celloidin coating. One of the most frequent causes of annoyance from this source, but a rapidly disappearing one, is the use of blistering applications by patients in an effort to thwart the need for surgery.

In emergency work the above outlined course cannot, of course, be used. The shaving and washing must be followed instantly by the application of the chemic antiseptic and grease solvents. This may require to be begun and finished in a very few minutes, as in cases of intra-abdominal hemorrhage—the field is splendid for reception of bacteria, the vital resistance is reduced in proportion to the hemorrhage, the time allotted for antisepsis is short, and the means applied necessarily meager. Here only the most acceptable agents must be thought of, and their success is a good index to their general usefulness. Aside from the methods ordinarily in vogue, there are two to be mentioned as of especial value. One is the use of Harrington's solution after washing and shaving; only a few minutes are necessary. The other is the application of tincture of iodin to the skin over a wide enough area. This must not be placed on after a motley fashion, but thoroughly, abundantly, and uniformly, so that it may find its way into all the open mouths on the skin glands. If any viscus should protrude through a wound it, too, should be covered with the iodin.

The Grossich Method.—The tendency in antiseptic work is to combine the simplest with the most efficient and quickest. The Grossich method, or a modification of it, is very excellent and very easily done, requiring four or five minutes when emergency demands it. The skin is swabbed off with a 1 per cent. solution of iodin in benzene after a dry shave; this swabbing is repeated three or four times, using fresh swabs each time. A small ball of cotton is held with a pair of forceps, and pressed firmly down against the skin. On to this cotton tincture of iodin is poured in sufficient quantity to smear over the region and wet the skin with it. This is repeated a time or two and the work may be begun. If there is time, the same washing and shaving may be done as by ordinary methods, and the Grossich method administered after the anesthetic is well under way, but it fails to sterilize the surface if it is moist. (See Iodin as an Antiseptic.)

Sterilization of Mucous Membrane.—In the preparation of mucous membrane for surgical work the mouth, the vagina, and the bladder must be considered. It is too frequently accepted as a truth that these fields cannot only not be sterilized, but cannot be improved by antiseptic effort, save in case of the vagina. The mouth should receive, first, the attention of a competent dentist, who will cleanse the teeth with as little laceration of the gums as possible, and fill, even if temporarily, the cavities present. The food and water used during preparation should always be sterilized, thoroughly wiping the teeth and the whole buccal cavity with gauze and a mild antiseptic solution, such as Thiersch's solution or a 1 per cent. carbolic acid solution, or, better still, 50 per cent. alcohol, must be done immediately after taking food. The interdental spaces are to be cleansed with floss silk prior to the rinsing and wiping. If inflammatory or suppurative processes are found they must be cured at the outset. At the last preparation after the anesthetic is given the mouth will be scrubbed with soap and water and then with 70 per cent. alcohol. This method gives unmistakably better results than the haphazardous trust of everything to the excellent circulation of the tissues about the mouth.

The rectum is prepared for operation by emptying the bowel with a brisk purgative, given thirty-six hours prior to operation, so that all motions may cease and the excessive peristalsis subside beforehand. The food given during this thirty-six hours must be scant and leave but little residue in the gut. Large enemata (saline) should be given two or three times on the day before operation, and another from two to four hours prior to beginning the anesthetic. The region surrounding the anus is prepared by one of the usual methods of sterilizing the skin. At the time of operation the rectum may be washed, using soap and water and swabs on a sponge-holder, then with 50 per cent. alcohol, followed by saline solution.

The vagina may be prepared by practically the same methods as the skin, but it is not so tolerant of antiseptics as the former, although it tolerates alcohol and 1 : 2000 bichlorid of mercury solutions without harm. Scrubbing of the vagina is of utmost value, since it is filled with folds and creases which will never be reached by a careless nurse. The iodin method is the best.

The bladder usually contains few or no bacteria. If they are present in urine, large quantities of water, with 7- to 10-grain doses of hexamethylentetramin every four to six hours for a few days, will reduce the number or eliminate them. If residual urine or inflammation of the bladder is present, systematic catheterization three or four times a day, and irrigation with a weak solution of potassium permanganate or bichlorid of mercury or a standard boric acid solution or even normal salt solution, tend to eliminate the infection. If the source of infection is the kidney substance or its pelvis, it will continue to pollute the bladder unless it can be dealt with by flushing and the administration of hexamethylentetramin or by direct irrigation. At the time of operation the bladder should be washed several times with salt or boric acid solution.

Sterilization of Accidental Wounds.—The same mechanical methods of sterilization that are used in uninjured surfaces are applicable to wounds. If it is a penetrating wound, care must be had not to allow entrance of solutions or débris into the serous cavity. All hair, blood-clots, grease, dirt, and devitalized tissues must be removed from the wound; the region must be shaved and the whole surface, wound and all, must be thoroughly washed, using green soap, or its tincture, and water. Benzene or iodized benzene, 1 per cent., may be used to the greatest advantage, especially in wounds of the hands of mechanics and trainmen. This antiseptic is used after the mechanical cleansing with non-aqueous solutions. If a bichlorid solution is employed, the mercury is precipitated by blood and serum, and so must be applied in a constant stream, or the part must be immersed in several succeeding solutions. It has a deleterious effect on the tissues of the wound surface; for these two reasons it is far from satisfactory in this class of work, and is less valuable probably than normal salt solution. Lysol or carbolic acid may be used pure, or in adequate solutions, and followed by alcohol. These may be used even on so delicate structures as the brain substance, when lacerated and infected; they must be so applied in such cavities that they cannot escape into surrounding spaces to cause mischief later. Tincture of iodin may be used the same way with the same good results. It may be followed with alcohol to remove the excess, and should not be used on large wounds, to be closed subsequently without drainage, lest iodism result. Harrington's solution is effective in this class of work, but is more destructive to tissue than either lysol, carbolic acid, or iodin. In lieu of these more efficient agents alcohol may be poured into the wound or applied on sponges for a few minutes. All these drugs are painful, and, if the wound is large, it is better to anesthetize the patient before applying them.

Sterilization of Instruments.—Every instrument in the surgical armamentarium should be made of material that will tolerate boiling; unfortunately, frequent boiling untempers cutting instruments somewhat, and, for this reason, many surgeons object to having knives and scissors so sterilized; others boil them and take the consequences. Temper is lost much more readily if the instruments lie in contact with the vessel next to the flame. Every instrument is to be thoroughly cleansed as soon as used; this prevents rusting and drying of body fluids on their surface. Besides, they are ready for sterilization when needed again. The water must be boiling when the instruments are submerged in it; this drives off the excess of oxygen and prevents rusting; the addition of soda, 1 per cent. of the carbonate, is further corrective against rusting; besides, it raises the boiling-point to 219° F., an advantage, especially in high altitudes. The instruments should never be boiled less than ten minutes. Pouring boiling water over them is a snare and a delusion. If the instruments are to be carried some distance before using they must be separated, dried with sterile towels, and reunited, or rusting will occur. Knives should be protected by wrapping with cotton to avoid dulling and gapping their edges. It is better to boil them separately, if at all.

Those instruments which are not boiled may be immersed in pure carbolic acid or lysol in a vessel with a spout at one corner, so that the fluid may be poured off; alcohol is then poured over them. In case water is used for this purpose instead of alcohol, they should be thoroughly rinsed before using, since carbolic acid lies undissolved on the under surface or at the bottom of the vessel and burns the tissues it touches.

Pans, receptacles, and apparatus are to be sterilized by the same method as that given for instruments. In emergency, pans may be sterilized fairly well by pouring a little alcohol into them, bringing it into contact with the whole surface, and setting fire to it; continue, while the flame lasts, to shift the position of the vessel so that the blaze comes often in contact with the surface. It is to be thought of only when boiling cannot be done, a rare occasion, and should not be ranked among acceptable methods.

Sterilization of Dressings and Fabrics.—These are to be wrapped loosely in cloth fastened with pins and sterilized with steam, preferably under pressure. Boiling them in water sterilizes just as satisfactorily, but it leaves them wet, an insurmountable objection for many uses.

Rubber goods are sterilized by boiling; they must be wrapped and kept away from the sides and bottom of the boiler.

CHAPTER III

THE PROCESS OF HEALING

WHEN an injury is done to tissue an effort is put forth to bring it back as nearly to normal as possible to repair the derangement produced. It may be understood in the beginning that the repair is most often only a repair and not a restoration of the injured or removed tissue in kind. There are three fundamental histologic elements concerned chiefly in the repair of tissue. One, two, or all of them may be produced in the healing of the same wound. These elemental tissues are tegumentary cells, white fibrous tissue, and bone, all physiologically passive tissues. If any further restoration of actively functionating tissues occurs, it is well; examples of this will be given in detail later. The rule remains, however, that bone is repaired by bone, epithelial coverings by multiplication of epithelial cells, and the remaining tissues by white fibrous tissue, or scar tissue.

The process of healing is also known as the healing of wounds, the repair of tissues, the process of repair, and the healing process.

Broadly speaking, it may be stated that the more highly organized a tissue is, or the more specialized an organ, the less it is capable of reproducing its functionating cells. It is shown by embryologists how tractable the tissues of lowly organized animals and of early fetal developments are, so that, by dealing with these, they may very materially alter the course of development in the adult forms. After specialization is finished and the perfect structure of the higher types of animals is reached this adaptability is lost irreparably. The blood may be spilled and replenished by blood, bone by bone, fibrous tissue by fibrous tissue, epithelium by epithelium, but a portion of the muscle removed is lost, and glandular tissue, nerve-centers, and such like, when damaged, can only be patched by the almost universal new-formed tissue.

The same process as that manifested in the repair of wounds is shown in the presence of irritation, especially if it is prolonged. This will be discussed under Inflammation.

Healing of Soft Structures.—For the sake of simplicity this may be stated, therefore, to be one process; subdivisions of the process depends on circumstances under which the healing must occur, without alteration of a single essential factor contributing to the ultimate result and with no variation of the product when completed. These subdivisions are, therefore, concerned not with the mode of healing, but with the conditions found while healing goes on. There are three types of the healing process:

(1) Healing by first intention, healing *per primam*, primary union, direct union.

(2) Healing by second intention, healing of an open wound, or healing by granulation.

(3) Healing by third intention, or the union of granulating surfaces directly one to another.

Healing by First Intention.—The conditions under which primary union takes place are definite, and must be present, or a failure of direct union occurs. The surface of the wound must be clean and the mouths of the blood-vessels closed, so that the wound is dry. The wound surfaces must be approximated throughout their entire depth, and the structures holding them together must not be so tightly drawn as to shut off the circulation within their grasp. The preceding conditions are of relative importance, since primary union occurs in spite of failure to comply with one or more of them absolutely. The next condition is most important. There must be no infection; the wound must be aseptic; if there is contamination by bacteria, they must be in such numbers or so attenuated that the tissues can dispose of them without extensive cell destruction. Suppose, then, that the wound is clean, dry, and closed, there will remain a certain dead space, however narrow, into which blood and serum escapes until it overflows at the surface. Some of this fluid escapes on to the surface or the dressings, where it dries; in the former instance this constitutes a scab, narrow and long, which serves the single purpose of an impervious dressing. The fluid accumulated in the wound coagulates within the first twenty-four hours, sealing the surfaces and lips of the wound together as so much mucilage holds two sheets of paper together; it is a *mechanical bond of union*, and from the histologic standpoint is a foreign body, serving a temporary purpose, ultimately to be removed as healing advances. This mechanical bond of union fills every nook and cranny that may be present on the wound surface. The cells damaged by the agent producing the wound may practically be considered as a part of the mechanical bond of union, for they undergo degeneration and are disposed of by the same process as the clotted blood and serum.

Acted upon by the irritation of the trauma, the capillaries adjacent are somewhat dilated and a deposit of leukocytes is made about the wound surfaces and back into the tissues, a little beyond the limits of the injury. They completely surround the clot which seals the surfaces together. The vascular changes do not go beyond the stage of a slight hyperemia. In those wounds where no infection is present the hyperemic condition is not sufficient usually to produce any visible change more than a faint blush near the edges of the wound. The leukocytes begin their phagocytic action at once in clearing up the injured cells and attack the walls of the clot. The leukocytes are ultimately removed from the tissues; they, too, perform a service and are disposed of.

Soon after the above occurrence takes place there appear in the rear of the leukocytes large, irregular-shaped cells with large nuclei and abundant protoplasm; they resemble epithelial cells sufficiently to be spoken of as epithelioid cells; they are called fibroblasts, for from them the ultimate product of fibrous (cicatricial) tissue is developed.

The source of fibroblasts is a mooted question. It is generally accepted that they are descended from the neighboring fixed connective-tissue cells, and from the endothelial cells of capillaries, lymphatics, and lymph-spaces in the field of injury. There is also unequivocal evidence that at least some of the fibroblasts are brought to the field by the blood-current; the origin of them is not known. Fibroblasts are of various shapes, some round, others oval, some elongated and bipolar; others are multipolar. The mass of tissue made up of fibroblasts is known as embryonic tissue; there are no blood-vessels as yet developed in this mass.

The fibroblasts are the precursors of scar tissue. After fibroblastic tissue is well on its way there appear little processes, springing from the capillaries up into the embryonic mass. They are solid at first, very thin, and made up of granular protoplasm. They are outgrowths from the endothelial cells of the capillaries. The free end appears solid; as elongation continues the process begins to hollow out at the attached extremity and blood enters its base. These processes are called capillary buds. They grow into the embryonic tissue in great numbers; the free end of one unites with the free end of another, or, if it fails to find such in due time, it loops back and unites either with another original capillary or the one from which it sprang. At times they are seen unattached, appearing as blind tubes. These new-formed blood-vessels are named capillary loops. After the capillary bud begins to show a lumen the endothelial cells spread from the old capillaries and line it. When the free ends become attached the lumen is soon completed and the endothelial lining finished, so that a new capillary results, and the blood circulating through it is carried into the embryonic tissue.

After capillaries grow into embryonic tissue it is called granulation tissue.

While capillary loops are forming the embryonic tissue advances, and secondary loops spring from the first in the same manner until the capillary buds are able to meet from one side of the wound to the other, thus bridging the chasm occupied a few days ago by a lifeless clot, and thus establishing a vital bond of union.

The time required for the healing process to advance to this point is three or four days from the date of closure, if approximation has been perfect. It is longer if the approximation has not been perfect, inasmuch as there is a thicker clot to be removed. As the granulation tissue grows a few hours older the epithelioid cells become more and more elongated and thinner, while at their surface can be seen the fibrils of beginning connective tissue. It is not settled whether these connective-tissue fibers are derived from splitting up of the fibroblastic cells or are produced alongside in the intercellular substance. This much is certain, that, as the connective tissue becomes more abundant, the fibroblastic cells grow smaller, leaving only the nucleus and a small amount of cell substance (connective-tissue cells).

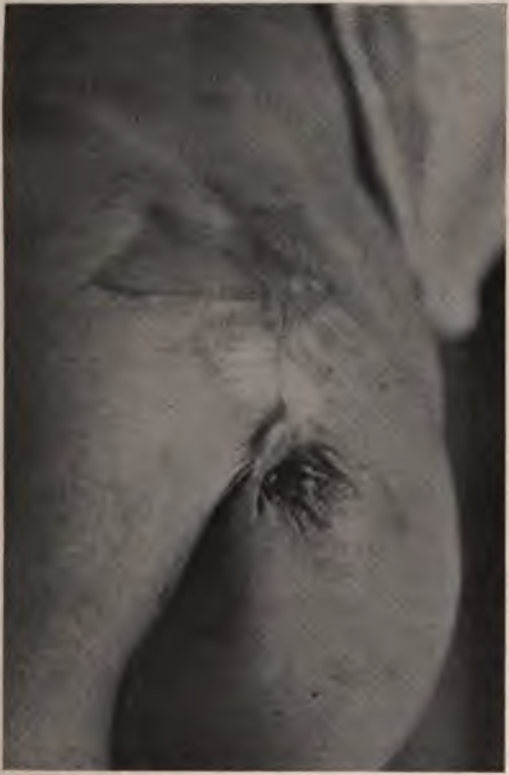

Fig. 1.—Cicatrization following a severe traumatism to lower back. Note displacement of the anal outlet.

Cicatrization.—On formation of the fibrils from the epithelioid cells these fibrils begin to contract, the last step in the production of scar-tissue. This contraction is due to the diappearance of moisture from the succulent new-formed tissues, and the whole granulation mass shrinks into a smaller volume. It is essentially a very slow process, and requires some weeks or even months for its completion. As contraction or cicatrization of the new-formed fibrous tissue takes place numerous small vessels coursing through it are collapsed, and ultimately obliterated. Hence, while in a newly formed scar the number of capillaries is greater than normal and the scar is red, in the cicatrix the number of vessels is much less than in normal tissue and the scar is pale. New scars can thus be readily distinguished from old ones. On account of the poor blood-supply of cicatrices they are incapable of resisting destructive agents as well as normal tissue and often ulcerate; for the same reason operation must not be made by incising large scars and trusting them to reunite on closure. They are either to be avoided or, if possible, excised at the time of operation; the circulation of cicatricial tissue is too poor to trust in an important place. The denser the scar is and the larger, the more likely it is to succumb to gangrenous, ulcerative, and inflammatory changes when damaged by incision or when called upon to do more than maintain its own existence.

Epidermization.—As soon as the mechanical bond of union is established the tegumentary cells limiting the periphery of the wound begin to spread inward by multiplication, to cover the rent in the skin or mucous membrane; they advance, as the granulation tissue does, until the gap is covered. The whole thickness of the skin is not regenerated; only those cells whose function is the passive one of covering in the underlying structure are developed; no hair-follicles, therefore, no sebaceous or sweat-glands, no papillæ, are found over the cicatrix. It is simply covered with tegumentary epithelium.

From the time of closure of a clean wound to the formation of the mechanical bond of union is twelve to twenty-four hours; from the time of appearance of the mechanical bond of union to its destruction by the leukocytes is two or three days; from the time of removal of the mechanical bond of union to complete establishment of granulation tissue is two to three days. So the period of time from the production of the wound to constructive completion of healing is about six days. Short of this time stitches are rarely removed, except for special reasons and in small wounds. Those wounds made in very vascular regions, such as the face, complete the process a day or two sooner; while those made in tissues which have a poor blood-supply require a little longer time.

At this stage of the healing process the work must not be considered finished. It is easy to enter a blunt instrument through the granulation tissue of a healed wound at the sixth day or even later. This is productive of little or no pain, since there has been no regeneration of nerves this early in the new-formed tissue. The fragility of the new-formed tissue has a very practical bearing, in so far as there is great tendency on the part of some operators to rush their patients out of bed and away from the hospital at the earliest possible date. If no tension is to be brought upon the scar no harm results; if tension is to be brought by such action, more or less stretching of the scar ensues; this may be carried to such an extent as to render the necessary support void, or it may produce severance of the new wound edges subcutaneously, and produce a postoperative hernia. No wound should be trusted to resist tension or pressure short of two or three weeks after operation, particularly in that class of cases so well illustrated by herniæ. There are other conditions, outweighing this one, that at times compel the surgeon to take chances with the wound; they are not routine.

In the older subdivisions of the process of repair healing by blood-clot was mentioned as one of the five. It is the same as the process described above, except that in healing by blood-clot the separation of the wound surfaces is greater, the mechanical bond of union wider, and the time requisite to finish the building of granulation tissue across it proportionately extended. In truth, primary healing is nothing less than healing by blood-clot, with the clot reduced to a minimum thickness.

Healing by Second Intention.—When circumstances are such as to preclude healing by primary union, wounds are left the alternative of healing by second intention or as open wounds. The conditions favorable to primary union may be present at the outset, but later, owing to accident or infection, especially such virulent infections as streptococci, they may be so altered as to compel a change from first to second intention. Healing by second intention may occur in wounds that have been closed, from inability of the tissue to establish under the circumstances some of the necessary steps of primary or direct union; infection is the chief cause of failure of primary union in closed wounds, which, if it be intense enough to cause inflammatory reaction or suppuration, invariably results in a more or less exclusive failure of primary union; sutures tied too tightly and dressings producing marked pressure may so interfere with the local circulation as to cause non-union. Certain constitutional conditions, of which the most notable perhaps is diabetes mellitus, may render the tissues unable to respond to the demands of the healing process, and so produce failure. Under all such circumstances healing, if occurring at all, must be by second intention. In all cases, when the nature of the wound or the circumstances present render it impossible or inadvisable to make closure, healing by second intention occurs, so it is called healing of an open wound. It occurs in these cases in the presence or in the absence of infection. In many conditions where surgical procedures are resorted to for the relief of pathologic lesions due to infection, such as abscess or fistula in ano, it is necessary to deal with the lesion in such a manner as to warrant healing from the bottom, or by second intention. Hence, healing by second intention is not to be looked upon as an unfortunate variation from the ideal type of healing, but as a very useful means of accomplishing drainage, on the one hand, while, on the other, closure of the cavity drained is being accomplished by the formation of granulation tissue.

Healing by second intention utilizes the same elements in its accomplishment, and these elements are derived from the same sources as in primary union. Let us take an ideal wound for this type of healing—it is open, a part of the skin has been removed or destroyed, and closure is thereby rendered impossible. No mechanical bond of union forms or can form; there is no union. The hemorrhage controlled, the wound is cleansed, the dressings are applied. There will be considerable oozing of serum and lymph and blood into the dressing in the first twenty-four to thirty-six hours. This is afterward reduced, as a rule, to a serous exudate. The same vascular changes occur around the base of the wound as in primary union. There are a number of leukocytes deposited in the upper layers of the wound surface among the crippled cells and on the surface. Numbers of them escape with the discharging serum and are wasted. Fixed connective-tissue cells, lymphatic and capillary endothelial cells, and perhaps cells brought from remote points in the circulating blood contribute to originate fibroblasts, the accumulation of which constitutes a covering of embryonic tissue for the healthy underlying region. These become granulation tissue by receiving capillary loops, and are soon converted into rudimentary fibrous tissue which cicatrizes after a few days. Cicatrization has additional importance in this class of wounds, for, being attached to the whole of the raw surface, when contraction takes place the edges of the wound are gradually drawn in toward the center, making the surface area continually smaller as long as the healing process continues. The epidermis begins to cover the granulation tissue at the periphery, and gradually spreads inward as the wound cavity fills up until the scar is covered by epithelium. The new-formed epithelium appears as a narrow ring, $\frac{1}{20}$ to $\frac{1}{10}$ inch wide, surrounding the raw surface.

Epidermization is very materially helped by the process of cicatrization, for, as the epidermis is building new integument, the contraction of the scar-tissue is continuously narrowing the area to be covered, so that the actual area covered by new epithelium is often no more than one-fourth or one-half the size of the original wound. The laxity of the tissue in which the healing occurs exerts great influence on the result accomplished by cicatrization. The looser the tissue, the greater the contraction and the smaller the size of the scar; the contrary proposition is also true; the denser and more inelastic the tissue, the larger the scar.

The presence of infection and pus in such a wound does not alter the process in one essential point, so long as it does not completely suspend it; it only delays the end by destruction of some cells and by the inhibitive action of toxins on others.

The Appearance of a Wound Healing by Second Intention.—At first, of course, there is only the raw surface, with more or less serum present. The various tissues, muscle, fat, tendons, fasciæ, nerves, and vessels are easily distinguishable. On the second day the wound, if its surface has not been disturbed by dressings, assumes a somewhat glazed appearance, due to coagulation of the albuminous fluids on the surface; it does not interfere with the process, and is prevented by dressings. On the third day granulation will be noted on the surface; it is covered densely by very small elevations composed of new-formed cells. They are a bright red color, and have so changed the appearance of the wound surface that now one tissue cannot be distinguished from another, since granulation tissue has covered them all with a uniform hue. Bone, cartilage, and tendon do not become covered so soon. Around the edges will be observed the faint bluish-white line of epithelium, creeping inward from day to day.

The steps of the healing process all advance at the same time; as soon as the field is ready the fibroblasts begin to form; as soon as they are multiplied into sufficient numbers, the blood-vessels grow into them; as soon as this is done, the granulation tissue begins to be converted into fibrous tissue; and as soon as this is old enough, it begins to cicatrize; so they march from this time on in the order named above, in a tier from the beginning of fibroblastic multiplication to the capping of the last gap with epithelium.

There is a class of wounds healing by second intention in which the depth, though sufficient to destroy the epithelial covering, has not destroyed the numerous glands and hair-follicles dipping down into the corium. Such wounds are superficial brush wounds, burns, and frost-bites of the second degree, and the wounds resulting from cutting Thiersch skin-grafts. In all this class the epithelial covering is very quickly replaced, due to the islands of epidermization springing from the mouth of every gland and follicle, as little white dots in a red sea of granulation tissue. This leaves little to be done by the surrounding border of epithelium. In these cases the hairs are reproduced and the skin glands continue to functionate as before, and the skin is left ultimately scarcely distinguishable from the surrounding uninjured area.

The growth of scar tissue in large wounds healing by second intention may, before the process is completed, so interfere with the circulation to the granulating surface as to make the rate of healing tediously slow, or stop it altogether, and render the tissues it contains an easy prey to invading bacteria. To prevent this, and to be rid of the slow process of epidermization, the surface may be skin-grafted in every instance where it requires more than a few weeks for the wound to cover in.

Healing Under Scab.—In the older subdivisions of the healing process healing under scab was given as one type. It is in no way different from healing by second intention. The scab, made up of dry discharges, blood, serum, or pus, or a mixture of these, does not alter the process underneath in its effort to meet the conditions present. If there is no infection, the scab serves to protect the delicate granulation surface from injury; if there is infection or pus, the scab holds these beneath and the process is retarded thereby.

Healing by Third Intention.—This is a combination between primary and secondary healing. In primary union the wound is closed from the beginning; in healing by second intention it is open throughout the whole period; in healing by third intention the wound is open at least long enough for granulation tissue to be well under way, maybe much longer, and afterward these granulating surfaces are approximated and unite. Healing by third intention, therefore, is the union of two granulating surfaces. As the preceding two types have been shown to be serviceable in surgical work, so is healing by third intention. A wound may not be capable of approximation, owing to swelling or other cause; when the swelling subsides, a few days later, the surfaces already granulating are approximated by suture and unite. It becomes necessary to drain a large wound; at the time of insertion of the drainage material a provisional stitch or two is inserted; at the end of a few days the drainage, no longer necessary, is removed, and the sutures, being tied, approximate granulating surfaces. Many operations require to be done at two or three sittings, called two-time or three-time operations. By the time the surgeon is able to finish the last step the wound made at the first is healing nicely by second intention. It is now closed, and heals by third intention, otherwise the operations done at more than one sitting would in many instances become unpopular or impracticable. In healing by third intention it is necessary that the approximation be well done, and that infection be absent or of such mild grade that the tissues can easily cope with it. If the granulation tissue is very abundant and in the way of accurate closure it may be adjusted by cutting or curetting. Granulating surfaces in contact with each other soon adhere by a mechanical bond of union, just as in healing by first intention.

In the healing process generally, the less the tissue is damaged, and the less infection there is present, the more quickly and easily will healing occur. Infection and suppuration have no essential, on the contrary, only a harmful, rôle to play even in healing of open wounds, and it is the surgeon's duty to protect these against contamination as carefully as if he expected primary union.

Mention was made at the beginning of the discussion of the healing process to the effect that there was one process of healing. In the following pages the apparent exception to the rule will be elucidated. Suffice it to say here that these apparent exceptions belong to the regenerative process and take place in connection with, or subsequent to, the healing process without interfering with the physiologic processes that create a bond of union to restore continuity of tissue at the site of every wound.

Healing of Nerves.—It has been clearly stated already that there is *one* healing process, and mention has been made of the apparent exceptions of certain tissues of the higher order which are re-established in function after section; of this class the most important is the nervous system. The process which re-establishes the histologic continuity and the function of severed nerves is not the process of healing. This process performs a certain work, so far as bridging the gap made is concerned, and so far as the injury of the adjacent tissues may render it necessary, but severed axis-cylinders and their sheaths do not reunite; the healing process simply catches the severed ends into a cicatrix and holds them there. In fact, the more abundant the cicatrix resulting from the process of repair, the less likely nerve function is to be restored. Severed nerves do not reunite; if their function is resumed, it is as a consequence of degeneration followed by regeneration of the axis-cylinder and the white substance of Schwann.

Section or rupture of a nerve results in complete degeneration of the nerve-fibers distal to the point of injury, and a similar degeneration of the distal end of the fibers proximal to the injury as far as the first or second node of Ranvier. This degeneration begins immediately and continues during and after the formation of scar tissue in the damaged tissues. After degeneration is accomplished the terminal nodes of Ranvier swell and fibrils sprout out from them; these fibrils penetrate the newly formed cicatrix and enter the neurilemma of the old nerve, growing along this as a guide until nerve-endings are established over the original ultimate distribution with more or less accuracy and function is resumed. Separation of the severed ends and the formation of cicatrices interfere with, or preclude the possibility of, such nerve regeneration, and here the distal end of the proximal fragment is found ensheathed in a nodule of connective tissue, such as occurs in amputation stumps. When separation is so wide that the ends cannot be approximated, even after stretching the nerve, the intervention of a guide, such as a segment of a nerve or the interweaving of several strands of catgut, facilitates the guidance of the new-forming fibers to their destination. The avoidance of large quantities of cicatricial tissue is brought about in two ways: first, by aseptic technic; second, by implanting the sutured nerve-ends in a muscle, where the union of the tissues about the nerve wound will result in the least possible scar formation. The same end is accomplished by ensheathing the sutured nerve in a segment of a vein or similar material.

Those cases of nerve suture, apparently resulting in immediate union, are to be explained on the ground that the total nerve supply to the part was not severed, as is seen in collateral nerve distribution, where two or more nerves send fibers to the same region, and in the anastomosis of nerves distal to the point of injury.

The time required for return of function of a severed nerve depends on the distance the injury is from the distribution. There will be no re-establishment of function for a few months and many months may elapse before the process is completed. It is but reasonable that the shorter the peripheral segment of the nerve the sooner the process of regeneration will be completed. The functions do not return simultaneously. Trophic action is first restored, sensation follows, and lastly motion. Complete restoration of function often fails; it varies from total failure to perfect physiologic activity; wide separation of severed ends, infection, and large cicatrices reduce the chance of re-establishing function.

One school of neurologists holds that regeneration takes place from both the proximal and the peripheral segment, claiming that there are present in the myelin sheath neuroblasts, which, when degeneration is finished, replace the axis-cylinder around which is formed the white substance of Schwann, and that these new peripheral fibers unite with the outgrowing ends of the proximal fibers. Whether this be true or false, it is certain that after avulsion, in which the total structure is removed, a redistribution often takes place.

Regeneration of Tendon.—Severed tendons heal with better function if sutured, still the severed ends may be separated some distance without interference with the result, provided immobilization be maintained. In case the tendon sheath contains more than one tendon it is safer to do plastic lengthening or suture. The severed ends of the tendon retract and the space is filled with blood-clot, which surrounds them like a callus. It organizes, and there appear in it spindle-cells, which seem to originate from the inner surface of the sheath. These cells lie, for the most part, parallel to the tendon axis. Beyond this the process does not differ from healing by blood-clot. When the process is completed the new-formed tendon can scarcely be distinguished from the old. It seems that the interval is filled by tendon regenerated from the tendon sheath. If this process fails, the sheath unites to the retracted cut ends within it. This at times results in fairly good function.

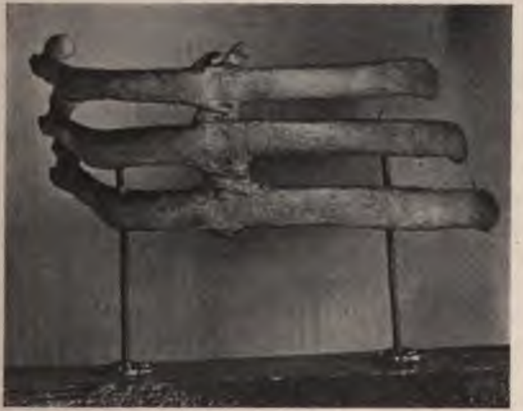

Fig. 2.—Three fractured ribs united by an excessive callus.

Regeneration of Muscle.—Severance of muscle is followed by the development of granulation tissue, followed by cicatrization, except in so far as it may be replaced by muscle-fibers growing into it from either side. The fibers next to these undergo longitudinal division and form new fibers, which grow into the forming cicatrix from either side, and meet and "interlace with one another like the fingers of clasped hands." If the injury is small, the gap may be filled largely with new formed muscle-fibers; if large, and especially if poorly coapted, considerable quantities of the cicatricial tissue remains, and only here and there will muscle tissue invade it.

Healing of Bone, Union of Fracture.—When the continuity of bone is interrupted the separated ends or edges bleed, and if, as is the rule, the surrounding muscles, tendons, and fasciæ are injured, they contribute their quota, and a blood-clot forms between the fragments and around them, extending well out into the lacerated tissues. The size of this clot may be increased by undue manipulation to elicit crepitus, too often an unwarranted practice, or by moving the patient without first securing immobility.

The periosteum becomes thickened and vascular and loosened from its bony attachment for a short distance from the fractured edges. The fat contained in the marrow at the site of injury disappears and a hyperemia appears. Granulation tissue is found filling the broken ends of the medullary canal. The clot is disposed of by the same absorptive process as in healing by first intention. When the granulation tissue is well under way, at the expiration of seven to ten days, the osteoblastic cells, from the marrow that has taken part in the formation of the granulation mass, begin to deposit bone in the ends of the medullary canal and the intervening space, producing an internal callus. All the bone formed in the healing of the fracture is at first soft and cancellous, later hardening, at times until it is denser than normal bone. At the same time the marrow cells begin to form bone, deposits of it are also noted at the angle between the periosteum and bone, where separation has occurred. If a periosteal bridge is present the same phenomenon may be observed in the granulation tissue underlying it. Production of bones continues in these two places, in the medullary canal, and in the mass of granulation tissue surrounding the fragments until the ends are held as by a vise. So far no ossification has occurred between the cortical surfaces. The surrounding cancellous bone is known as provisional callus, and its purpose, with the internal callus, is to maintain the fragments in rigid fixation while cortical union occurs.

While the ensheathing and internal callus are forming, bone absorption is taking place in the cortical portion of the fractured ends; the bone becomes much less dense, the jagged, rough edges are smoothed down and the granulation tissue covers the ends and invades the intervening space. This is the last productive step in the process. Cancellous bone is formed, uniting the fragments, and gradually this is made denser by deposits of bone from the osteoblasts which lie within the cancellous spaces until compact bone is formed.

Cartilage is observed at times in the midst of the granulation tissue as an antecedent of bone formation; it is usually in small quantity and is by no means constant.

The new-formed bone uniting the severed cortical portions is called the permanent or definitive callus.

The internal callus is absorbed after perfection of the definitive callus, and the canal filled again with marrow. The provisional callus likewise disappears more or less completely by the action of osteoclasts, and the periosteum resumes its normal relationship. The accuracy of approximation of the fragments and perfect immobilization have much to do with the size of the permanent enlargement at the site of fracture. When these two conditions are complied with, there will remain little or no evidence that the bone has been broken. Poor approximation, angulation, separation of the ends, and imperfect immobilization, if they do not result in delayed union or non-union, will cause the persistence of a much larger callus.

Under certain circumstances, many of them not understood, the tissues seem unable to produce bony union, but return to the usual process of healing in soft structures, and unite the thinned and pointed fragments by cicatricial tissue, or, by an attempt at the production of a joint, or pseudarthrosis, in which there appears a capsule, holding the ends together; within this capsule is a cavity containing a small amount of serum, and the ends of the fragments are covered with an imperfectly developed hyaline cartilage. In other instances the fragments are simply held together by a cord of fibrous tissue.

The time required for ossification to begin depends on the patient's general condition and the blood-supply to the bone in question and the surrounding tissue. In bones well supplied with blood ossification begins by the sixth or seventh day; in those poorly supplied, from the tenth to the twelfth day. In the old the healing process does not occur as readily as in the young. However, some authorities claim that ununited fractures are seen most frequently during the fourth decade of life. Healing of fractures likewise varies in time. Small bones, well supplied with blood, may heal by the end of fifteen or twenty days. The average time is from a month to six weeks, although the definitive callus may not fully form till the expiration of several months.

SKIN-GRAFTING

Operations that leave considerable areas of tissue uncovered by integument, and other surgical lesions which must heal by second intention, are hastened materially by employment of skin-grafts. The amount of cicatricial deformity is reduced to the minimum, and in ulcerative processes cure may be seen from the use of grafts, where failure or extensive deformity could only be expected without them.

Skin-grafts are derived from the individual on whom they are to be transplanted, from another individual of the same species, or from an individual of another species. In the first instance, they are called autografts; in the second, heterografts; in the third, zoögrafts.

Preparation of Field.—When grafting is to be done on a newly made wound the only precautions necessary are the stoppage of all bleeding, and avoidance of contact of antiseptic or other agents harmful to the tissues with the wound surface. This work must be aseptic, not antiseptic. There must also be no torn and devitalized shreds or pieces of tissue on the surface; it must be mechanically and bacteriologically clean. When the grafts are to be translated to a granulating surface, all infection should have disappeared, and the surface should be covered with healthy granulation tissue and free from pus. Absolute freedom from infection is an impossibility here as elsewhere, and in many cases, if one waited for perfect asepsis, the grafting could never be done; practically, therefore, the closest approximation to the ideal must suffice. The field is prepared as for any other operation; if the grafts are to rest on the undisturbed surface of the granulations, which may suffice unless they are too uneven, no antiseptic shall be used—it reduces the chances of success. If the surface granulations are to be removed—the better plan—the whole surface may be treated with antiseptics, just as in preparation of the skin. Removal of the superficial parts of the granulation surfaces and of the unevenness may be done by scraping with the edge of a knife, by cutting, or by the use of a brush with stiff, small, closely set bristles. The latter is far the easiest and readiest method, and, in case it is used, the

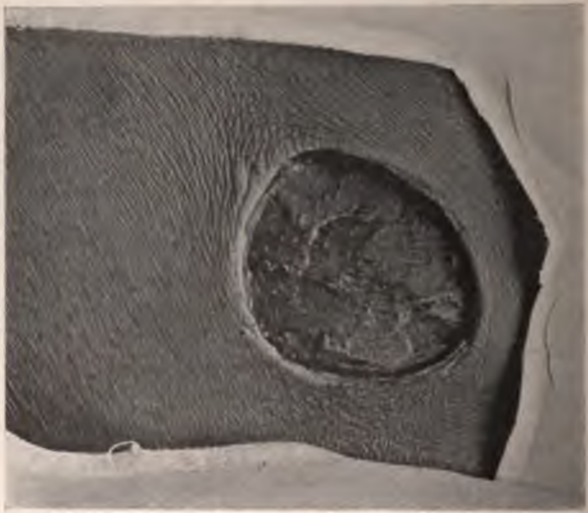

Fig. 3.—Denuded surface ready for skin-grafting.

tincture of green soap and water in contact with the cells does little injury if, indeed, any. After washing, the surface should be rinsed with normal salt solution and the bleeding controlled by pressure and hot water, but not hot enough to devitalize any cells. The bleeding controlled, and the surface dry and clean and smooth, the grafts may be placed in position according to the method used.

Preparation of the field from which the grafts are to be taken may be done by any of the methods for asepticizing the skin. Here, too, care must be taken not to harm the skin cells by vigorous chemic antiseptics, and such as have been used should be thoroughly washed from the surface.

In grafting very large areas it may be necessary to secure heterografts; other conditions arise which make this the more feasible plan, for example, the presence of a skin disease in the patient. Care must be used in selecting the donor of the grafts, especially to avoid the transmission of syphilis.

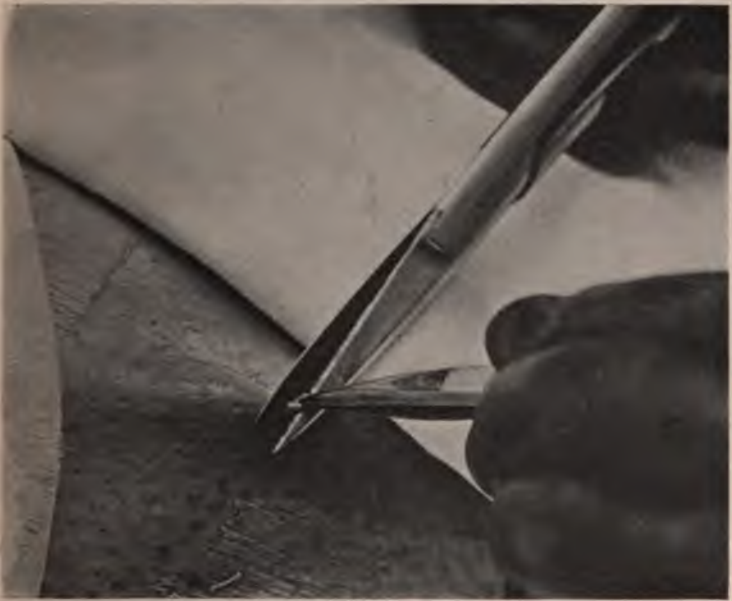

Fig. 4.—Cutting graft. Reverdin's plan.

Reverdin's Method.—The grafts are to be taken from a well-selected surface, usually the front of the thigh or the back of the outer surface of the arm. They are small in size, $\frac{1}{8}$ inch in diameter approximately, and consist of cuticle and a small thickness of the cutis; they are cut scarcely deep enough to bleed at most more than a drop. They may be taken with or without the administration of a general anesthetic. This is the only method that can be practised readily with local anesthesia or, in some instances, with no anesthetic. Cocain may be administered hypodermically or endermically in weak solution, or ethyl chlorid may be sprayed on the surface. The latter method is too slow, and if freezing occurs, as it must to produce anesthesia, the grafts are not so easily obtained. Pinch up a small bit of the skin surface with a pair of fine thumb forceps and with scissors snip off the graft. It is transferred directly to surface of the wound or ulcer and placed carefully where desired; press down gently and guard against inversion of the edges of the graft. Sometimes it is recommended that a round needle or a small tenaculum be stuck into the upper layers of the skin and lifted away from the skin, when the grafts are to be cut by scissors. This offers no advantage over the use of forceps, and has the objection of allowing the graft, after cutting, to turn easily on its hold, and is likely to result in some of them being applied upside

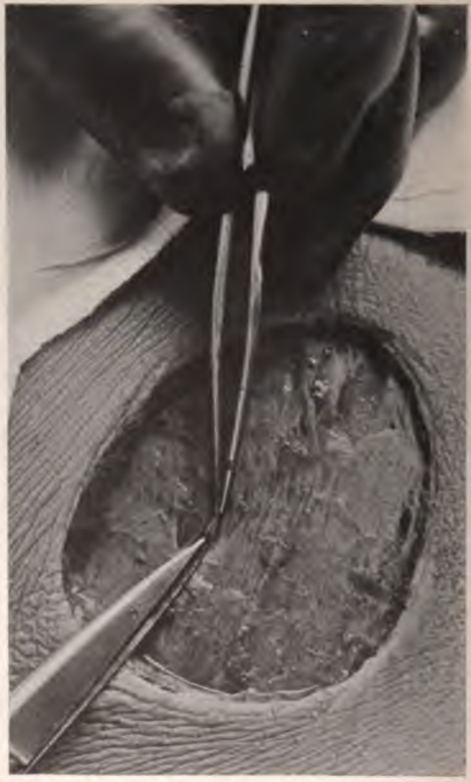

Fig. 5.—Placing graft. Reverdin's plan.

down, unless the most painstaking care be observed—the use of smooth forceps avoids this trouble and the consequent delay. The grafts may be placed from $\frac{1}{4}$ to $\frac{1}{2}$ inch apart, as the individual operator may choose. It is better to place them fairly close if possible, as a goodly percentage is often lost. The value of a very few such grafts must not be underestimated, however, as they spread over considerable areas, and are valuable even when no more than a half-dozen live.

After the grafts are in position the surface may be treated in one of two ways, namely, by placing a dressing in immediate contact with the surface, or by dressing in such manner that nothing touches the grafted area. The former is carried out by applying strips of silver foil or gutta-percha tissue, aseptic but not antiseptic; these strips are cut narrow, $\frac{1}{4}$ to $\frac{3}{4}$ inch wide, owing to the size of the ulcer, and long enough to extend on to the healthy surrounding skin at each end. They are applied imbricated, each overlapping the preceding one, so as to allow escape of surface discharges into the overlying dressing. If a single sheet of material be used for covering, it must be perforated at many points with small apertures. The dressing applied must not be bound tightly enough to interfere with circulation; the looser the dressing, provided it is not loose enough to slip and dislodge the grafts, the better will be the results. Another item of importance is that bulky, hot dressings should not be used, as an excessive retention of heat will increase the number of grafts failing to take.

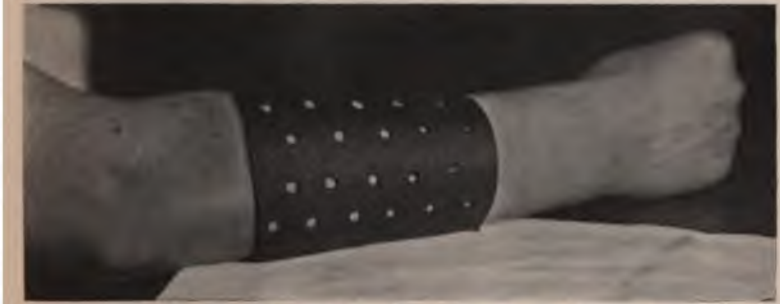

Fig. 6.—Perforated dressing for covering skin-grafts.

The second method of dressing is preferable when feasible. A frame is to be used in such manner that the dressings do not touch the surface. The frame is fastened above and below the wound, or on all sides, and the dressings applied over this so that protection and ventilation will be good, and in sufficient quantity to protect against the small amount of discharge. It is similar to a vaccination shield only on a larger scale.

The dressings are not to be removed for four or five days. At the change of dressings the grafts have disappeared from view unless rather large. Later, they show up as bluish-white islands, scattered over the red field of granulations. and then rapidly extend until the whole surface is covered..

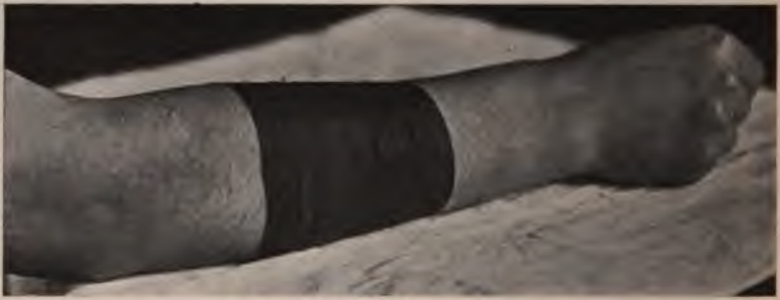

Fig. 7.—Imbricated dressing for covering skin-grafts.

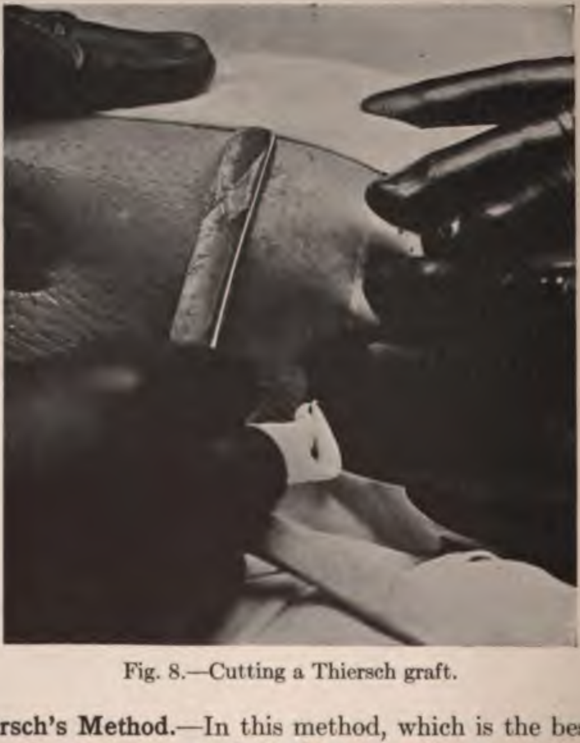

Fig. 8.—Cutting a Thiersch graft.

Thiersch's Method.—In this method, which is the best under ordinary circumstances, and at the same time capable of rapid xecution, thin strips of the upper layers of the skin are cut and laced in position so as to cover the granulating or raw surface ntirely. The thickness of the grafts is sufficient when they include he general cells of the stratum papillare.

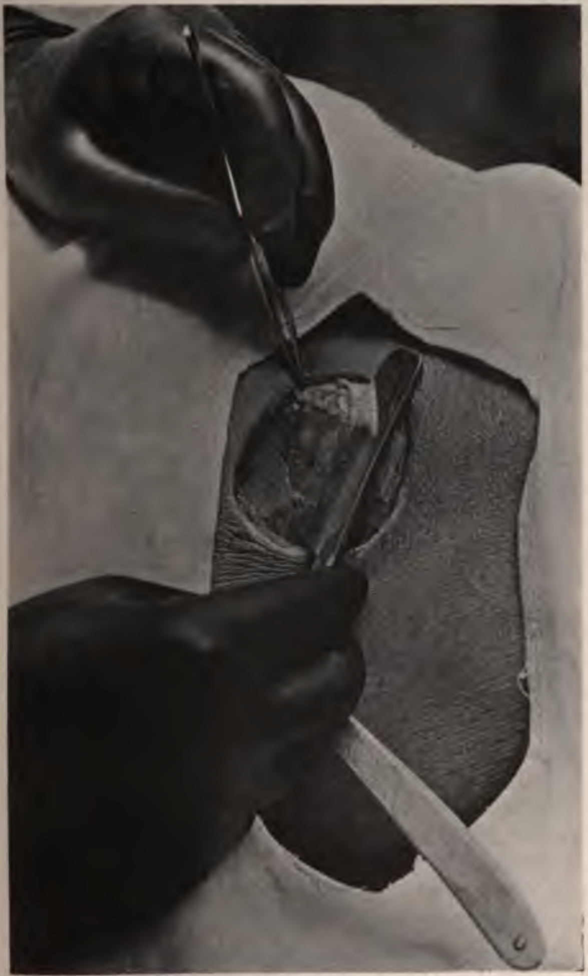

Fig. 9.—Placing a Thiersch graft.

Cutting the Grafts.—The knife used should be very sharp and not hollow ground—a razor, a catlin, a long bistoury, or an amputating knife will serve the purpose very well; better satisfaction will be had if the blade is fixed immovably to the handle. The chief objection to using an ordinary razor is the difficulty arising from the movable handle. The skin from which the grafts are cut, usually the anterior surface of the thigh or the outer, anterior, or posterior surface of the arm, must be sterilized and shaved unless the hair be rudimentary. The skin is now rendered tense by skin hooks placed at each extremity of the surface from which the grafts are to be cut, or by holding the skin taut with the hands or by other device. As the cutting is done the graft folds itself on the surface of the knife if the blade is broad enough, and may be transferred directly to the surface to be covered. This process will be repeated until enough cutis is obtained to cover the whole area.

Placing the Grafts.—The surface of the wound or ulcer must be prepared just as described in Reverdin's method, all oozing checked, and all clots removed from the scraped surface. If bichlorid of mercury is used it must be followed by abundant irrigation with warm salt water solution; it will hardly be necessary to use antiseptics on the granulating surface, as, if the infection present be sufficient to demand it, it will be time well spent to combat the infection a few days longer before grafting. It requires but little judgment to understand that infection of the surface will cause disintegration of the clotted serum which forms between the graft and the surface it covers, just as the mechanical bond of union of wounds healing by first intention is destroyed by infection, and the grafts die. If any accumulation of fluid is noticed lifting some parts of the grafts up from the surface, it must be gently pressed out, so that they may lie in closest contact with the subjacent structures.

The grafts are to be placed so that they overlap the edge of the surface surrounding the wound or ulcer; they must be placed exactly in contact with each other along their edges, or they may slightly overlap; every precaution is taken to prevent their edges from curling under, as no "take" will be had at such points. This tendency to curl under is the chief objection to running the grafts through a normal salt solution at or slightly above body temperature, although this immersion in the solution does not interfere with the vitality of the flaps or the success of the work. It even becomes necessary to use the salt solution in those cases where work is done with unskilled assistants, and where, owing to the location of the ulcer, direct transfer of autogenous flaps cannot be done.

During the cutting of heterogenous grafts the donor should be anesthetized, preferably with nitrous oxid.

Dressings.—The dressings most useful here are the same as those described under Reverdin's method. However, failure to have the necessary material at hand should not deter one from utilizing this method, as most satisfactory work may be done by applying fluffed iodoform or plain gauze, which is to be strapped down with adhesive plaster to prevent gliding, and then covered with adequate quantities of gauze or cotton and bandaged in. This point must be remembered, namely, that too early change of the gauze lying next to the grafts endangers success; this gauze, therefore, lying under the adhesive straps should not be removed until the expiration of seven to twelve days, and then cautiously after throughly saturating with salt solution. Of course, if local or constitutional conditions demand their removal, the possible sacrifice of the grafts must be accepted.

Wolfe's Method.—As Reverdin's method utilized only small bits of skin from the surface, and Thiersch's method large pieces of cuticle, so Wolfe's method employs the whole thickness of the skin cut in such shape and of such size that it will fit as accurately as possible the area to be covered. The same antiseptic and aseptic precautions are to be used here as in the preceding two. The same preparation of the granulating surface is to be done and the hemorrhage must be controlled absolutely. The additional provision of rendering the edges of the ulcer or wound vertical and smooth should be made to prevent unevenness at the border of contact. The graft is to be cut somewhat larger than the area to be covered, for contraction of the graft will reduce it to two-thirds or three-fourths its size before excision. Only the skin is to be taken; subcutaneous fat and fascia are not desirable, and if abundantly present will be the cause of failure. The utmost care must be exercised not to bruise the skin during preparation, and the gentlest dissection possible to avoid injury during excision of the graft.

Wolfe's method offers much less chance of success than Thiersch's or Reverdin's method; but when circumstances arise such that the contraction which comes to a certain extent with the above-named methods would interfere either with the cosmetic result or more especially with the practical usefulness of the part, as in cases where the skin has been lost from the palm of the hand or the sole of the foot, then Wolfe's method deserves trial, and repetition of it if necessary. The edges may be sutured to the surrounding skin or may be held in place by gentle uniform pressure. It cannot be too strongly emphasized that heavy pressure and gliding of the grafts are certain to preclude union.

Krause's Method.—Another method makes use of the total thickness of the skin. The avoidance of injury, the careful dissection, the use of no subcutaneous tissue, and the vertical section of the skin surrounding the site of grafting hold as in Wolfe's method; here, however, the skin is cut in long narrow strips from the thigh, back, or arm, and allows easier closure of the wound. These strips are placed side by side until the breach is covered. They are not sewn, but, if successful, soon adhere at their adjacent borders. In both the Wolfe and the Krause method the graft becomes cyanotic and loses its epidermis. As the circulation is established they gradually assume their normal color. Infection renders either of these methods fruitless. Great care should be exercised not to bruise the skin during preparation, and the gentlest dissection possible must be done to avoid injury during excision of the graft.

BONE-GRAFTING OR TRANSPLANTATION

Besides skin-grafting, the most useful and most widely applicable transplantation of tissue is that of bone, which is done to replace deficient bone or to establish bony tissue where it is entirely wanting.

The sources of bone-grafts may be the patient's own tissue, the amputated or excised bone of other human subjects, or of the lower animals. The grafts may be used in the form of a number of small pieces, bone-chips, or as a single specimen of sufficient size. They may be used fresh or dried, and with or without previous sterilization by boiling, but they must be aseptic. They may be placed in position at the time the defect is made; if the bacterial conditions are favorable, this is the better course; if not, then at some suitable subsequent sitting. They may be used to replace the whole thickness of bones, as, for example, the tibia after resection, or they may only fill out a partial defect. They may be held in position by nailing with ivory pegs, such as are used in the immobilization of fractures, or held by the tissues, if the

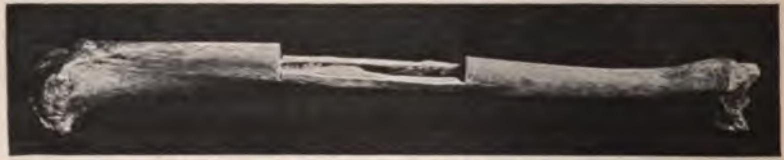

Fig. 10.—Tibia from which a bone-graft has been cut.

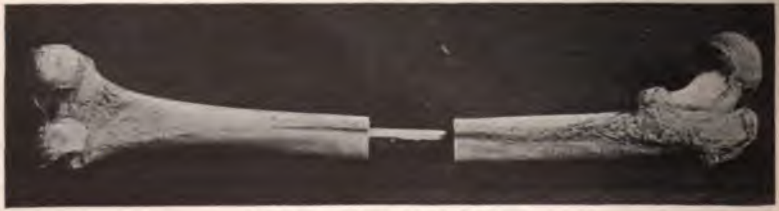

Fig. 11.—Bone-grafting.

bone continuity has not been interrupted, by the mechanical devices useful in the treatment of fractures, or the graft may be set in a socket in the fragment at each end.

The success of bone-grafting depends on the perfect cleanliness of technic; it is the process of healing by blood-clot in which the sterile bone is to become encysted, and failure of asepsis will produce the same clinical manifestations as those seen in necrosis of bone and the same pathologic result, namely, destruction of the included portion of dead bone.

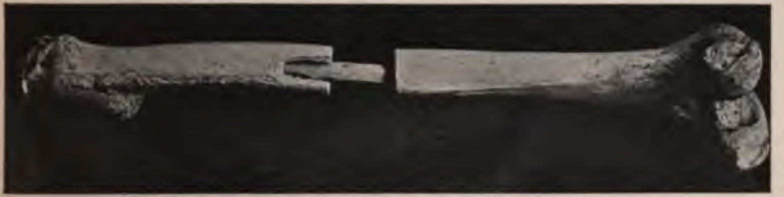

Fig. 12.—Bone-grafting.

The process of repair of defective bone is utterly unlike that of skin-grafting—in the latter the graft lives and grows; in the former the graft may be dead to begin with or, if not dead, it may die,[1] and is dealt with by the tissues as any other foreign substance buried in them, by being absorbed as much as possible, and by being surrounded and penetrated by the tissue formation. The earthy material, however, remains, and serves as a framework of the new bone to be built on the ruins of the old. The presence of such earthy material stimulates the deposit of similar new material and assures the formation of bone instead of the usual cicatrix.

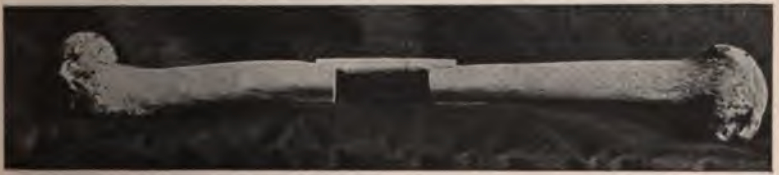

Fig. 13.—Bone-grafting.

The length of time requisite for completion of the process depends, necessarily, on the size of the fragments and the activity of the process; it is more rapid when fresh bone is transplanted than in the cases where dried bone is used; likewise, it is more rapid when periosteum can be brought to cover the grafts more or less completely, or when the graft carries its own periosteum and marrow. The time required for immobilization should be governed by the rules for fractures at the point under treatment and should be even longer.

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[1] There can be no doubt that some bone-grafts do not lose their vitality altogether.

In defects due to various diseases affecting the bones destructively, such as osteomyelitis and caries, and in those where resection of the bone has become necessary as a result of tumor formation, the results obtained from bone transplantation are very satisfactory.

Mucous Membrane.—Transplantation of mucous membrane, very similar in the entire details to skin-grafting, but requiring much more delicate work, is useful, especially in eye surgery. The grafts are obtained from lower animals, usually the rabbit.

Grafting of Other Tissues.—Transplantation of muscles, tendons, and nerves has usually a different meaning from the application of the term as used above. In these, the suturing of a tendon, nerve, or muscle to a new attachment is done without severing it from its vital connections in the body. Thus, a tendon may be transferred from a posterior to an anterior insertion, and the muscle be thus converted from a flexor into an extensor; or a nerve that supplied a certain group of muscles be severed and united to the distal portion of one whose center has failed, and a sacrifice of the first group be made to re-establish function in the more important group; however, tendons and nerves may be easily and successfully transplanted to fill out the spaces left by destruction of these tissues. Fascia is also transplanted with the most flattering success, as may be illustrated by the transplantation of the dense fascia of the outer surface of the thigh to correct defects in cases of hernia.

Blood-vessels may be grafted with success, thanks to the recent investigations of vascular surgery, by suturing a segment between the severed ends of an injured vessel, and the thyroid gland may, with some degeee of success, be transplanted into the body of patients suffering from hypothyroidism. So far it seems impossible to make the engrafted gland continue its function indefinitely.

Various other materials are used in the correction of bodily defects, but they depend for their efficacy on a permanent mechanical support, and in no way are replaced by living tissue, remaining as encysted foreign bodies, subject to the dangers of such.

Transplantation of entire organs, such as kidneys, has been performed experimentally, but has as yet assumed no practical value, for, while a more or less perfect function may be established and maintained for a time, failure comes after a few months and atrophy and loss of the engrafted organ follows.

CHAPTER IV

INFLAMMATION

Definition.—Inflammation is the response of living tissue through the blood-vessels and the blood to an irritant, by means of which an attempt is made to remove that irritant, to limit its spread or action, and to repair the damage done by it.

It can be seen by close study of the above definition that the inflammatory process, instead of being a diseased condition, is an effort called forth by adequate cause for the purpose of correction of defects produced, or the prevention of lesions that would of necessity follow if no intervention were made. It is a curative, a reparative process, and must be looked upon as such, both from the standpoint of pathology and therapy, the real disease being the irritant. The definition above does not embrace the secondary parts played by the nervous system or by the various tissues in which the process may appear; these facts will be developed as we proceed.

The nature of the irritant active in the production of inflammation is usually chemic, and may be either an organic compound, which is practically always the case, or inorganic. If non-chemic agents serve as the cause of inflammation, it can scarcely be considered as being more than the healing process.

Termination "Itis."—The termination "itis" is used in medical literature to signify inflammation, the structure affected by the process being indicated by the word to which "itis" is appended.

This termination is suffixed to the names of tissues, and then signifies inflammation of those tissues without reference to the part of the body so affected. So adenitis signifies inflammation of lymph-nodes; myositis, inflammation of muscles; osteitis, inflammation of bone; cellulitis, inflammation of cellular or connective tissue; with no reference in either instance to the particular nodes, muscles, or connective tissue affected.

"Itis" is similarly appended as a suffix to the names of organs or other anatomic entities, as appendicitis, inflammation of the vermiform appendix; hepatitis, inflammation of the liver; vaginitis, inflammation of the vagina; stomatitis, cystitis, nephritis, and so on. But here no indication is given of the particular part or tissue of these structures involved, unless further specified.

Terms.—It is wise here to give a number of terms, used as descriptive of the inflammatory process, as they are employed in medical parlance. They are classified into groups for convenience of study, but must not be considered as a classification of the inflammatory processes, since many of these terms might with propriety be applied to the same condition at one time, and since some of them are of questionable propriety.

Relative to Cause.—(1) Infective. This term denotes an inflammatory process, the cause of which is an infection with at least one species of pathogenic bacteria. The term has additional significance, in that the inflammatory process may be induced in other tissues by accidental transfer of the bacteria producing it.

(2) Traumatic inflammation signifies that trauma, or injury, is the cause of the condition. Trauma is usually accepted as only the predisposing cause, yet, since the injury so reduces the vitality of the tissues as to render them more easily susceptible to bacterial ravages, the term is admissible if thus understood.

(3) Sympathetic inflammation is used to indicate that a cause of inflammation may be found in the nerve-supply of the part. Irritation of the periphery of a nerve may so affect another tissue, supplied by a different branch of the nerve, or by a nerve whose center is in close functional relation to its own, as to predispose to or produce an inflammation of the structures supplied by the second branch or nerve. The most notable example of this is sympathetic ophthalmia.

(4) Neuropathic inflammation, closely allied to sympathetic, means that from some disturbance of innervation, whether it arises from central or peripheral causes, a reduction of the vitality of a part may arise to the extent of favoring the least exciting cause.

(5) Hypostatic inflammation is produced by the accumulation of blood in a part due to its dependent position and the inability of the heart to drive the blood actively through it; this stagnation of blood is nothing more than a passive congestion; the failure to get a proper supply of blood reduces the resistance of the tissues and they are then easily attacked.

Relative to Duration.—(1) Acute inflammation signifies that the process has arisen within a short period of time, a few hours or days, and usually runs a short course, and subsides within a few days or a few weeks at most, unless it becomes either subacute or chronic.

(2) Fulminating inflammatory processes may be described as very rapid in development and violent in activity. The development of this type occupies usually only a few hours. It is hyperacute.

(3) Chronic inflammation means one of long duration. It may have originated as an acute process and become chronic, or it may

be of such nature at the beginning that its chronicity is recognized then. It lasts for months or years. The symptoms and signs are usually less marked than in acute. It is not unusual to see acute exacerbations of chronic inflammatory processes; this is due to trauma, or other accident, or to secondary infection.

(4) Subacute is sometimes used to signify an inflammation intermediate between acute and chronic.

Relative to Activity.—(1) Sthenic inflammation is a very active process, with marked local and constitutional symptoms. It is the type seen in robust, vigorous individuals, and may be said to be an excessive reaction to the poison invading the body. A good example is lobar pneumonia as it appears in strong and vigorous men, with high temperature and slow, full, bounding pulse.

(2) Asthenic inflammation is the very opposite of the latter. It occurs in those whose bodily vigor is unequal to the demands, and in those who are overwhelmed by the poisons absorbed and whose symptoms, while less marked, are often more alarming. In this type there is usually a lowered temperature and a rapid, feeble pulse. The term asthenic conveys the idea of exhaustion.

Relative to the Tissue Involved.—(1) Parenchymatous inflammation attacks the functionating cells of an organ, the parenchyma. The chief value of this distinction lies in the fact that if the parenchyma of vital organs be attacked by an inflammatory process, their failure to functionate for a time may produce grave or even fatal results. An illustration of parenchymatous inflammation is acute parenchymatous nephritis.

(2) Interstitial inflammation signifies that the connective tissue of an organ is attacked. Illustration, interstitial nephritis.

(3) Diffuse inflammation, while used loosely, has the special significance, as applied to organs, of inflammation of the total structure, embracing, therefore, both the parenchyma and the connective-tissue framework. The term is also loosely employed to signify a widely spread inflammation, as of the skin or peritoneum.

(4) Serous inflammation means that affecting any serous membrane.

(5) Catarrhal inflammation. Catarrh is inflammation of the mucous membrane. It is not different from the inflammatory process elsewhere, except for the structure attacked. The characteristic giving it the name is the free discharge of mucus or mucopus.

Relative to the Product.—(1) Plastic, adhesive, fibrinous, or fibrinoplastic inflammation always occurs on a serous surface and is characterized by the deposit of fibrin. This fibrin may simply cover the surface as a false membrane, or, if two surfaces lie in contact, it seals them together, forming an additional barrier to the advance of the causative infection, and preventing a free escape of infected fluids from the primary focus into the surrounding cavity; it thus becomes the chief means of early limitation of an infection in serous cavities, especially in the peritoneum. If the inflammatory process is very rapid there is often no evidence of fibrin deposit and unlimited spread of the infection is possible. The fibrinous deposit is usually largely or entirely disposed of if the offending organ is properly dealt with early; if not, it later becomes organized into fibrous tissue and remains permanently, capable of later disturbance by interfering with peristalsis or producing intestinal obstruction, or causing malposition of viscera in the abdomen, fixation of the lung, and limitation of the breathing capacity in the pleura, or ankylosis in the joints.

Plastic deposits invariably follow drainage of the abdominal cavity, whether infection is present or not, but they are usually absorbed.

(2) Purulent or suppurative inflammatory processes are those in which pus is produced. They may be manifestly suppurative in certain instances, while in others it may require the utmost vigilance to determine this point.

(3) Croupous or diphtheric inflammation is an inflammatory process attacking mucous membranes, on the surface of which a false membrane of a fibrinous nature is deposited. This membrane may be separated from the mucous surface on which it forms, or may become dislodged in the course of the disease causing it, and give trouble. Croupous inflammation is found more often affecting the pharynx, the upper air-passages, and the larynx and trachea. Pathologically, no important distinction can be made between croupous and diphtheric membranes, although a constantly diminishing number of physicians claim a clinical distinction, in that the membrane of a croupous inflammation may be separated from the underlying mucous membrane, leaving the latter intact, while the membrane of a diphtheric inflammation cannot be removed without taking with it the upper layers of the mucous membrane which were incorporated during the period of formation of the false membrane, and thus the mucous surface is left raw and bleeding. The difference is considered chimeric by pathologists, and may be dismissed as useless, either in a clinical or pathologic way.

(4) Gangrenous inflammation is sometimes loosely used to signify an inflammatory process which has terminated in the death of more or less tissue, and is of value only because it indicates that the process is violent, as in fulminating processes, or that the resistance is poor, as seen in asthenic cases.

(5) Proliferative inflammation indicates that new tissue has formed, or is forming, as a result of chronic inflammatory changes. This may easily result from plastic processes, in which the fibrinous exudate is maintained until its organization into fibrous tissue and permanent adhesions made up of living connective tissue result. Proliferative inflammation is found in chronic interstitial nephritis, and the new-formed connective-tissue contracting causes the kidney to become smaller in size, and thus sacrifices the functionating portion to the proliferative results of an old inflammation. So, again, this type may be seen affecting joints which have long been inflamed and maintained immobile by virtue of the disease, or as a plan of treatment, and ankylosis be established by the new tissue. This may be illustrated again in the effects of inflammation on bone and bone-producing cells, only here the new tissue is osseous, and a bone whose periosteum has been long inflamed may more than double its diameter.

(6) Moist inflammation is seen on mucous surfaces and indicates simply that there is a discharge, watery, mucous, or mucopurulent in character.

(7) Dry inflammation indicates that there is no discharge, and has reference to the mucous membrane as the antithesis of moist inflammation.

(8) Hemorrhagic, in which there is a tendency to bleed, as in acute pancreatitis.

Relative to the Course.—(1) Healthy inflammation indicates that the inflammatory process is running a satisfactory course to recovery. The term is ill-advised and but little used, since the very presence of inflammation would suggest disease rather than otherwise.

(2) Unhealthy inflammation is one running an unsatisfactory course and showing signs of evil tendencies.

(3) Latent inflammation is one which has run its course without sufficient clinical evidence to warrant a correct diagnosis, and perhaps has caused little or no inconvenience to its host. Such inflammatory processes often run on until the hope of cure is lost before an attempt is made to learn the cause of trouble. They are usually chronic, and Bacillus tuberculosis stands at the head of the list as the cause of them.

Etiology of Inflammation.—The causes of inflammatory changes, wherever they may occur, are very definite, though they may not be patent in a specific case. They are subdivided into predisposing and exciting. It is appropriate here to make it clear that the predisposing causes cannot of themselves excite a true inflammation; that the exciting causes may be present, and fail to produce inflammation unless the predisposing causes have first prepared the way; finally, that the exciting causes may be in certain instances so potent to produce inflammation as never to fail, whether a single predisposing factor has been present or not.

Predisposing Causes.—This embraces all factors that reduce the resistive powers of the body to onslaughts from agencies which demand an inflammation for their relief or removal. These predisposing factors may pertain to the whole body or to some organ or part which is influenced deleteriously, while the body as a whole may remain free from their influence.

(1) *Deficiency in the Quantity of Blood* (*Oligemia*).—Whatever may be the nature of the cause that reduces the total quantity of blood in the body sufficiently to make an impression on the function of any or all the component structures, the blood becomes less efficient along the lines of antibacterial resistance, and, by so doing, makes easier the invasion of the tissues by the exciting causes of inflammation. This may be a general anemia resulting from hemorrhage, as is seen in cases of tuberculosis pulmonalis, in postpartum hemorrhage or any bleeding from any surgical condition, such as traumatism, postoperative bleeding, or that from ulcerated malignant tumors. The cause or source of the hemorrhage is non-essential; the important fact is that hemorrhage shall have occurred in extensive quantity.

Deficiency in the quantity of blood is also a result of prolonged and exhaustive diseases, as typhoid fever independent of hemorrhage, or in tuberculosis and syphilis if improperly treated. The failure of the blood-making organs to manufacture it in keeping with the demand results, by slow stages, in the same reduction of the volume of blood as hemorrhage does in a brief period.

The reduction in the quantity of blood may be purely a local matter, and serve the same end for the part concerned as if the total volume of blood were reduced to the same degree. This local condition, in its broad sense, means that an insufficient quantity of blood is circulating through the vessels of the part, whether from arterial obstruction, which does not permit the blood to pass, and leaves the vessels distal to the obstruction incompletely filled or filled only as an inadequate collateral circulation may afford, or from a venous obstruction, which, while it keeps the vessels overdistended continuously, yet does not permit the blood to return to the heart and lungs with sufficient rapidity to maintain its normal state. Both factors can be operative at the same time.

Obstruction to the circulation is especially due to the pressure of tumors on the vessels, to thrombus and embolus, and to ligatures applied in continuity. Thrombi are produced avoidably by injury to the veins during operation or by undue traction on them, especially in the abdominal cavity, and by improper postoperative treatment of surgical cases, especially if that surgery is done in the pelvis. Ligatures applied to veins or arteries must be so placed if possible to allow the best collateral circulation, and ought to be applied with the least possible separation of the vascular sheaths from the vessels and consequent rupture of the vasa vasorum. This observation is especially important when it is necessary to place the ligature close to an important collateral branch.

Traumatism, aside from the reduced resistance consequent upon it, reduces the circulation through the injured tissue in proportion to its intensity, and serves as a predisposing cause of inflammation. So true is this, that in many infections trauma is a frequent and important item of anamnesis. Experimentally, inflammatory processes can be produced with far greater readiness when the field has been prepared by trauma.

Stagnation of the blood or congestion, whatever may be the source of it, especially passive congestion, favored always by dependent position of the part, serves well as a predisposing factor. This is seen on the surface of the body more often in cases of extensive varicose veins. It is common knowledge how frequently the legs and ankles of patients having varicose veins in the legs suffer from localized inflammation, and how intractable such inflammation is once it has developed; how, too, sufferers from hemorrhoids are repeatedly harassed by inflammatory and ulcerative complications.

Vascular spasm, when long maintained, and, far more frequently, arteriosclerosis serve the same turn, inasmuch as they do not permit a sufficient blood-supply to pass through the lumina of the vessels. Hence, in the old, inflammation often follows slight injuries, spreads to an alarming extent, and fails to respond to treatment. Senile gangrene frequently follows slight injury and infection in individuals who have arteriosclerosis.

(2) *Deficiency in the Quality of the Blood* (*Hemolytic Anemia*) *or of the Tissues.*—Constitutional diseases, when severe or prolonged, not only have the effect of reducing the quantity of blood, but, at the same time, they much more certainly deprive it of protecting qualities and of its power to develop them when the demand is made. Under these circumstances not only does the present disease work its own ravages, but, at the same time, serves to predispose to other perhaps more fatal lesions. By producing poisons and turning them into the blood constantly, and by alteration of the proportion of blood elements, together with diminution of the patient's normal capacity to replenish these materials at the normal rate, it is easy to see how an additional foe could gain a foothold in tissue previously secure against it.

Tuberculosis in pure culture, severe enough, is greatly intensified when secondary infections gain admission to the partially devitalized field, and must be fought with a crippled blood. Diabetes mellitus, gout, rheumatism, syphilis, and rickets are other constitutional diseases tending in the same direction. Again, certain purely local disorders produce similar results; especially worthy of mention are cardiac lesions and renal and hepatic disturbances of such nature as to produce anemia.

Alcohol, when used habitually, reduces the opsonic power of the blood, produces sclerotic or fatty changes in the viscera, and directly and indirectly alters the fortifications of the body against disease. An illustration of this is the poor resistance alcoholics manifest against pneumococcal infection as compared with abstainers.

Starvation, whether it is due to improper food or to insufficient food, produces anemia, and favors the development of inflammation. This is observed perhaps more in young children who are being fed abundantly on foods they cannot digest, and, when an inflammation of the alimentary mucous membrane arises, their vitality is so impoverished by a full-fed starvation that they readily succumb.

The same causes that interfere with the supply of blood to a part are responsible for alteration of the quality of the blood retained in the part for too great a period. So this condition may arise: the blood is circulating so meagerly through the diseased field that it may not only be overcharged with refuse from normal tissue metabolism, but, at the same time, if infection be present, contain relatively large quantities of toxins and have a low opsonic index, while the opsonic index of the remaining blood is high and the relative amount of toxins low.

The following conditions have been, until within recent years, considered as exciting causes of inflammation, and are maintained as such by a few at the present day, but the only inflammatory process greatly concerning the surgeon is that caused by infection. These conditions are traumatism, excessive heat or cold (burns, scalds, and chilblain), chemic agents, such as escharotics and electric and *x*-ray effects. So far as trauma is concerned, it is evident that the non-infected injury shows no inflammation beyond that of the healing process. If this is true, then we can see no reason for not placing chemic, thermal, and electric injuries in the same group, inasmuch as the changes resulting from them, while conforming to inflammation up to a certain point, thereafter are entirely unlike true inflammation, especially as concerns their remote effects. Hence, we prefer to class all these injuries as predisposing causes of inflammation. From a pathologic point of view, and from the manifest intention of the process, those inflammatory processes produced by other causes may not be differentiated from bacterial processes.

Any combination of the predisposing causes may be active in a given case; in truth, in many cases of inflammation many factors have served to predispose to or favor the development of bacteria which have gained access to the tissues. All agencies predisposing to inflammation favor its continuance and spread.

Exciting Causes of Inflammation.—In the light of the above facts, it is proper that, from a surgical viewpoint, we recognize inflammation as being produced solely by bacteria—that is, by living causes—in whatever light we may accept, from a pathologic consideration, those changes wrought in the tissues in consequence of the action of trauma, heat, and cold, chemic agents, and electric and radio-active energy. The one supreme reason for exclusion of these, and acceptance of micro-organisms as the cause of true inflammation, is that the extent of the process produced by the former is definitely and absolutely determined by the extent of action during their application—*i. e.*, the amount of the dose and the corresponding reaction and no more. The changes wrought by these agents remain confined permanently to the field of application, and there is no invasion of adjacent tissue not affected at the beginning, nor of remote tissues by transmission of the cause to them from the primary site. Neither can the condition be transferred from one individual to another. So it is clear that such processes are of but little concern to the surgeon except in themselves. A far different thing is bacterial inflammation, such as is meant to be prevented by all modern efforts at antisepsis and asepsis, as is meant, in a word, whenever the term "inflammation" is used nowadays. True inflammation spreads from the atrium, giving admission to the bacteria which cause it, and it spreads because these bacteria are living organisms, and multiply and invade the tissues, or are carried by accident, by the lymph or by the blood, to new and uninvaded fields, causing similar changes in these new fields. The cause of inflammation is a multiplying agent, and so, when true inflammation is once established, it is capable of wide dissemination, and death of the patient may result without further contributions from outside the body. It is rare, indeed, that in a given case of infection the amount of toxins present in the bacteria at the time of introduction, or any amount they could ever produce, would have a deleterious action on the tissues in either local or constitutional manifestations; it is the power of multiplication, doubling their numbers at incredibly short intervals, and as often doubling their poison-producing capacity, that makes inflammation the dreaded thing it is. The process here mentioned is capable of transfer not only from tissue to tissue in a single body, but from individual to individual, by instruments, hands, dressings, and such like, which have come in contact with one case and without proper cleaning are allowed to be used on another. It has been shown in the chapter on Surgical Bacteriology that the immediate action on the tissues in all cases of infection is by the chemic poisons they produce, not the bacteria themselves.

Extent of the Inflammatory Process.—Various inflammatory processes are very different in intensity and extent; an infection of one individual with a certain strain of bacteria produces insignificant lesions, and another is infected from him and dies or becomes seriously ill. One species of bacteria habitually produces mild inflammatory changes, while another invariably produces violent processes. Certain bacteria usually produce chronic inflammation, and others as habitually produce acute inflammation. The extent of the ravages of inflammatory processes and the nature of those processes—that is, whether acute or fulminating or chronic—depends:

(1) On the resistance of the infected body, namely, the opsonic power and the alexins as well as the total quantity and general condition of the blood, and on the condition of the tissues infected; that is, the natural vitality and blood-supply of those tissues, and the extent to which predisposing causes may have been brought into action. Thus, a low opsonic index and a reduced total quantity of blood gives poor general resistance, and in certain of the local predisposing causes, as in trauma, burns, and frost-bites, when they have reached the extent of destroying or damaging a considerable amount of tissue, it is almost certain that more or less infection will occur, and very certain that the vital resistance will be poor in combating that infection.

(2) The virulence of the germs causing an inflammation, as has been shown already, may vary very widely for a given species, say a strain of streptococci, which, after passing through a few individuals, may become so intensified in virulence as to scarcely resemble its ancestry, and after a time become attenuated again by similar treatment with different hosts. These are well-known laboratory facts. Again, the habitual mild toxic powers of some, as Staphylococcus epidermidis albus, and the constant virulence of others, as anthrax and the Bacillus pestis (Kitasato's bacillus), shows how an extensive invasion of the former might be insignificant in comparison with a slight infection by the latter.

(3) The amount of the initial dose, or the number of bacteria constituting the infection at the beginning, influences markedly the result. A few bacteria may be introduced into a wound with

impunity; a few more may be added, and result in a slight inflammatory reaction, but when large numbers are introduced at one time they may so overwhelm the protective forces as to produce violent results almost from the outset. The initial infection is not usually sufficient to produce grave symptoms immediately, but when an encysted abscess ruptures into a serous cavity, or when a hollow viscus pours its contents through a perforation, the general effect may be so violent as to produce death almost before the inflammatory process has time to get under way. Hence, not only the initial dose, but the rapidity of general intoxication, dependent upon the absorptive capacity of the cavity into which infection has entered, are large factors in determining results.

(4) The rate of multiplication of bacteria is another potent factor for variation of results in infection. One group, of which streptococci head the list, multiply so rapidly and are so toxic that the defenses of the body cannot be marshalled until after the infection has passed beyond them—hence, septicemia is frequent with this infection; on the other hand, others are so slow to multiply that a chronic, though by no means an essentially mild, inflammation is assured from the beginning; such a one is the tubercle bacillus.

Phenomena of Inflammation.—What the local appearance of an inflamed tissue may be, whatever variations, circumstances, and locality may impose, whatever diversity and intensity local and constitutional symptoms may show, fundamentally the changes occurring in the inflammatory process are the same. If they vary in degree, or if they do not always produce the same pathologic result, it is because of relative resistance and virulence, and not owing to alteration of the process. The following changes may be observed under the microscope in any thin living membrane subjected to irritants capable of evoking inflammatory reaction.

The phenomena of inflammation fall into three subdivisions:

(1) The changes which affect the blood-vessels and the blood.
(2) Destructive or degenerative changes.
(3) Reparative changes.

(1) *Dilatation of the Blood-vessels.*—When an irritant acts upon the tissues in sufficient intensity to produce inflammation, the first change observed is dilatation of the small blood-vessels, venules, arterioles, and capillaries. This dilatation is due to paralysis of the vasoconstrictor nerves and to the direct action (paralytic) of the irritant on the musculature of the vessels; the lumina of the vessels, therefore, become of larger caliber, and admit an increase in the rate of flow of blood through them and an increase in the quantity of blood. The dilatation of the capillaries is passive.

(2) *Hyperemia.*—This increased quantity of blood flowing

through the dilated vessels is known as hyperemia, or active congestion. It means an increased flow of blood into, through, and out of the inflamed tissue, and is purely a physical phenomenon, depending on the diminished resistance offered by the dilated vessels. In case the endothelium of the blood-vessels is destroyed or damaged the increase in the rate of flow is not observed. This is seen where croton oil is injected into the tissues and in vessels damaged by trauma.

(3) *Congestion.*—After hyperemia has continued for a short time the blood-stream becomes slower and slower, the vessels become engorged with blood-cells in increasing numbers, until they are filled with the slowly moving columns of red and white cells. This is sometimes known as passive congestion. As the rate of flow becomes slower, the leukocytes drift on, more probably are drawn by their chemotactic power to the periphery of the stream, and glide or roll along the intima of the vessels until they finally stop in contact with the intima. The red cells keep to the middle of the stream. In congestion the blood flows into the vessels slightly faster than it flows out and engorgement of the blood-cells results.

Oscillation.—At the last of the stage of congestion the columns of blood-cells move with decreasing rapidity, until finally the propelling effect of each cardiac impulse is seen, with a slight advance of the column, which recedes somewhat during diastole, and a vibration back and forth continues a short time and ceases, the cells failing to be driven further by the heart-beats. This to-and-fro movement is called *oscillation*; it is not a step of the process, but a border-line between congestion and stasis; the end of the former, the beginning of the latter.

(4) *Stasis.*—This stage is not observed in all the vessels in which congestion has appeared, as in many of the vessels the stage of congestion is reached, remains for a time, and is replaced by more active circulation as the infection subsides or the irritant is removed. In stasis the blood-cells lie packed in the vessels (capillaries) with no evidence of motion. They have reached a standstill. The arrangement of the white and red cells remains relatively the same, the red in the center of the lumen, the white at the periphery.

(5) *Migration of Leukocytes, Exudation, and Diapedesis.*—These three processes do not follow the preceding in the order named here. They begin during the stage of congestion and continue through the stage of stasis.

(*a*) Migration of leukocytes means the passage of the white corpuscles, usually the polymorphonuclear cells, from within the vessels through the vessel walls into the perivascular spaces, where they serve their purpose of destroying bacteria, and are then known as phagocytes. The point of exit of leukocytes through the vessel walls is between the endothelial cells of the intima, where they are held together by cement. The method of passage of leukocytes through the capillary walls depends on the capacity of these cells to move like amebæ; hence the motion is called "ameboid movement." The leukocyte, lying against the intima, projects a small finger-like process of its protoplasm through the opening between the intima cells; this finger-like process is known as a pseudopodium. The protoplasm of the leukocyte now gradually flows or moves into the distal extremity of the pseudopodium, which lies outside the vessel; this outside tip of the pseudopodium therefore, becomes larger as the body of the cell lying within the vessel grows smaller, until nothing of it is left within the vessel. Now the finger-like projection is withdrawn from the intracellular crevice, and the leukocyte is free to wander to its destination in the infected region.

Migration of leukocytes takes place continuously in the normal body, apparently as a physiologic process, and in the healing process. The fullest passage of these cells through the vessel walls, however, occurs in cases of infection, where they migrate in numbers sufficient to invade and surround as a wall the whole field of infection.

(*b*) Exudation is produced at the same time as migration of leukocytes; it is more than a filtration of blood fluids through the vessel walls. The walls of the vessels become more permeable in inflammation, and the endothelial cells exert what is termed by certain authors a secretory function, pouring into the surrounding tissues substances which do not ordinarily come from the blood except under abnormal environment (the presence of toxins, etc.). This exudate differs from transudates and lymph in possessing a greater quantity of albumin. As the exudate is poured out, it fills the space with fluid and produces an edematous condition. It carries with it the antiseptic and opsonic properties of the blood and withal dilutes the toxin present.

(*c*) Diapedesis signifies the passage of red blood-cells through the vessel walls, which, so far as we know, is purely accidental and has no practical significance. The erythrocytes are thought to pass through the openings made by the leukocytes.

(*d*) Rhexis is another passive or accidental and unimportant condition. It means the rupture of small vessels and the escape of their contents into the tissues.

Rhexis and diapedesis occur inconstantly, and must be accepted, as stated above, as accidents; the important processes occurring under this division are migration and exudation.

Destruction of Tissue in the Inflammatory Process.—If we accept the term inflammation as meaning those local processes or reactions called forth by infection, and exclude the pathologically identical processes called forth by trauma, thermal, chemic, and electric agencies (the healing process), then there are certain changes of a destructive nature going on continuously in inflamed tissue, more marked and intense in proportion to the virulence and abundance of the causative bacteria. These degenerative changes are due to the poisons liberated by the bacteria acting on the tissues. If the circulation is sufficiently interfered with, the diminution of the blood-supply or its entire interruption adds further to the causation of necrosis. The tissues that die are partially or completely liquefied by the leukocytes and their ferments and by the digestive powers of the bacteria. If the amount of tissue destroyed is not too great in quantity, clinical evidences of such destruction are wanting, and all the dead tissue is removed from the field by living leukocytes. If the amount of destroyed tissue is too great to be handled in this way, it appears in observable quantities, in the form of necrotic masses or pus, and can be removed only by artificial or accidental means.

Regeneration or *repair* of the damage done by the irritants acting on the tissues is begun as soon as the irritants are removed or reduced in quantity, and in those cases where this end is not early accomplished the reparative process is begun at the outer limits of the inflamed area. This reparative process is in no way different from that described under the Healing Process, and accomplishes the same end by replacing destroyed tissue with connective tissue or bone, as the case may be. The regeneration of tissue here may go so far as to establish new-formed blood-vessels in a tissue normally devoid of them. Regeneration of parenchymatous tissue may also sometimes result from chronic inflammatory processes.

Inflammation of Non-vascular Tissue.—In tissue having no direct blood-supply, such as the cornea and cartilage, the inflammatory process develops in response to the application of the causes to those tissues. The vascular changes appear in the closest capillaries, and the exudate and leukocytes are carried to the field of action through the lymph-channels and spaces which normally convey nourishment to the parts. So that, while no vessels are present in these tissues, the essential factors contributed by the blood are soon brought into action, and the degenerated areas are repaired in the same manner, if more slowly and somewhat more uncertainly so far as may concern function, as where a direct blood-supply exists. The function of non-vascular tissues after inflammation is dependent on the same conditions as that of vascular tissue, namely, the extent of replacement of normal tissue by new tissue formation.

The Spread of Inflammation.—Those so-called inflammatory processes which are not produced by living agents in the tissues cannot extend from the place of application of the cause. A wound is made, calls forth a certain reparative inflammation (healing process) which concerns only the tissues damaged, and not in the least concerns remote or even adjacent structures. The same is true of the hypodermic injection of irritant chemicals and of burns. The process evoked by pathogenic bacteria, however, is a constant menace, not only to adjacent structures, but to various remote structures, even to the whole body, because of the fact that the cause may be transferred to other tissues, gain a footing, and produce a similar process there.

An inflammation may spread by four distinct routes—they are, by continuity, by contiguity, through the blood, through the lymph. It would be more accurate to state that bacteria causing a given inflammation may spread from their primary focus in either or all these ways, and wherever they find lodgment may establish a new process. It is not to be forgotten that the inflammation *per se* is a corrective effort.

Spreading by Continuity.—An infection, or inflammation, is said to spread by continuity when the process spreads in a single tissue or structure without involving other structures or tissues, and when it spreads directly and uninterruptedly in a single organ or part. For example, if an inflammation begins in the skin and spreads continuously from the atrium, but does not involve other tissues, it spreads by continuity. If the process spreads from the skin at the body apertures, and directly extends to the mucous membrane, it spreads by continuity; if in a bone, a joint, or other body cavity, the method is the same so long, and only so long, as it keeps within the bounds of that particular anatomic structure and spreads without interruption.

Spreading by Contiguity.—When an inflammatory process originates in one structure and spreads from it into an adjacent structure across a real or virtual chasm it spreads by contiguity. For example, the spread of inflammation from parietal to opposed visceral pleura illustrates the same method, from one coil of intestine to another in contact with it, or from the tongue to the roof of the mouth.

Spreading by the Blood.—If a few bacteria be contained in an embolus that escapes from the primary focus, and when lodged produce a similar process, the spread is through the blood. Or, as happens when the blood becomes generally contaminated with bacteria and various parts of the body become affected, the bacteria may lodge upon the intima of small vessels, especially where the blood-current is slow. This is seen in all metastatic infections, and is especially noticeable in metastatic erysipelas, as the inflammation is superficial and visible.

Spreading by the Lymphatics.—Just as the bacteria may be distributed indiscriminately by the blood, they are carried along somewhat more definite channels by the lymph-current, when they have gained an entrance into it, as they always do. Many times no clinical evidence exists, but it is very doubtful if ever an infection is present in which the lymph escapes. The infection, if intense, may produce a general infection of the lymph-spaces, channels, and nodes of the region affected. More often the former two escape and the infected lymph is carried to the nearest lymph-node downstream, which filters out the bacteria, and disposes of them if possible by means of its contained phagocytes, or, if this fails, becomes inflamed. If bacteria escape this node they go to the next, and so on, until the lymph is poured into the blood. Therefore it is possible for a septicemia to occur through lymphatic infection. Up-stream lymph-node involvement is said to occur, though somewhat rarely. It is explained on the ground that the normal outlet of lymph from the infected region has become blocked, thus necessitating a retrograde current, which forces bacteria into nodes that would escape if the channels had remained patent. The fact is of practical value, and should always be borne in mind when searching for lymphatic metastases.

To illustrate the methods of spread of inflammation, let us suppose the tongue has become infected and inflamed. First, the infection extends throughout the tongue by continuity. Second, that the mucous membrane of the palate becomes infected from contact, *i. e.*, by contiguity. Third, the submaxillary and, later, the upper cervical nodes become infected from bacteria carried through the lymphatics. Fourth, a suppurative focus is formed and a blood-clot blocking the mouth of a vessel, destroyed by the degenerative process, is disintegrated, and allows fragments of the infected clot to escape through a vein; these lodge somewhere, say in the liver, and produce an inflammation and perhaps one or more abscesses, or, if pus enters with the clot, they produce a pyemia.

Terminations of the Inflammatory Process.—The outcome of inflammatory processes is very variable, ranging from no perceptible final abnormality to the most extreme permanent impairment or loss of function and more or less complete destruction of tissue, and even the death of the patient, which results either from the general effect of the bacterial poisons or from impairment of function of vital organs. The termination of an inflammation may be expressed as the resultant of the combating forces, the tissues against the bacteria. According to the final balance of these forces the terminations are:

(1) Delitescence.
(2) Resolution.
(3) Suppuration.
(4) Gangrene.
(5) New Tissue formation.

(1) *Delitescence.*—When an inflammation is initiated, but by causes incapable of maintaining or firmly establishing a stand, and the usual stages are not developed, the cause being removed or overcome, whether by natural or artificial forces, it is said to terminate by delitescence. Delitescence is the cutting short of an inflammatory process or an abortive inflammation. Hyperemia, and even congestion, may develop, but the condition does not continue long, and subsides in a few hours to a day and a half subsequent to beginning. This termination is the result of a mild infection or of a marked resistance on the part of the tissues, such as partial immunity or of active therapeutic measures. In such cases the infection is early, easily, and completely overcome by the protective agencies of the body.

(2) *Resolution.*—An inflammation may run through all the stages—dilatation of vessels, hyperemia, congestion, stasis, diapedesis, and exudation—and yet the tissues not be much the worse after it is finished. Resolution has a positive and a negative significance. It presupposes a well-developed inflammation. Its positive significance is that there has been slight tissue destruction, slight enough to produce no gross evidence of it; that the tissues were able to overcome the infection and return to normal without perceptible portions of them being destroyed by the bacteria. Resolution signifies the most complete possible victory for the tissues. Negatively, resolution is that termination of an inflammatory process in which neither pus nor death of macroscopic portions of tissue occurs, and, therefore, is the ideal termination, unless, perchance, delitescence could have occurred or been induced, which is rare. It is the result of a fight between bacteria and the body cells and fluids, in which, however fierce the battle may have raged, and however grave the general condition of the patient, the bacteria are overcome by the protective agents and the least possible amount of repair is necessary.

(3) *Suppuration.*—This termination occurs in every instance where pus is found. The amount of pus may vary relatively to the total value of inflamed tissue, in one instance the whole of it becoming a suppurative mass, in another only portions of it, perhaps relatively very small portions, becoming purulent. The pus

may be so confined as to accumulate and give an exact measure of its quantity, while in another instance it may not be confined, and its escape admit of no adequate judgment of the quantity. Termination of inflammation by pus production is evidence that the bacteria have gained the victory to that extent, and the amount of pus is essentially an index of the extent of sacrifice of tissue. The leukocytes resisting the bacteria are poisoned by them until they, and somewhat of the tissues concerned in the inflammation, die, and become pus-cells. Surrounding the pus-forming area the leukocytes marshal their forces more perfectly and arrest further invasion, but the extent of pus formation is the measure of the victory the bacteria have won, though they may later be vanquished. It is manifest, therefore, that a wide area of suppuration, or prolonged formation of large quantities of pus, cannot fail to be a serious draft on the vital resources of the body, to say nothing of depreciation of their resistive capacity by continued absorption of toxins. When the process is finished, and pus has ceased to form, and when the inflammation surrounding the pus zone, not intense enough to produce pus, has resolved, the breaches made in the tissues are repaired by formation of cicatricial tissue. Recovery occurs, but the tissues are crippled.

(4) *Gangrene.*—When an inflammatory process is produced by toxins so virulent and so abundant as to destroy the vitality of a portion of the tissues affected, gangrene, or death of tissue, is established. This is favored by a predisposing trauma, which reduces the vitality of the cells and interferes somewhat with the vascular and lymphatic structures of the part; the recuperative powers are, therefore, crippled and poorly equipped to deal with their double task of controlling an infection and repairing traumatic injury. Of course, if the trauma be sufficient of itself to devitalize the tissue directly, or indirectly through destruction of afferent or efferent blood-vessels, no inflammatory reaction can occur. The swelling of inflammation, if it be severe, causes a diminution of the circulating blood and lymph, and permits undue concentration of bacterial poisons in the region concerned, and so favors termination by gangrene. Likewise, thrombosis, appearing in a considerable percentage of the small vessels, tends to produce the same result in the same manner. In a word, an inflammatory process may result in death of masses of tissue, when the infection is so virulent and so abundant, whether aided or unaided by other factors, as to overwhelm the tissues and kill them without admitting any adequate reaction on their part. The most frequent example of such processes is found in acute fulminating appendicitis.

In strict accuracy, it is better to consider gangrene as an accident happening during the course of, and because of, the inflammatory process rather than as a termination. Yet, if we are forced to admit that destructive changes habitually occur in inflammation, even those terminating by resolution, it becomes manifestly only a question of degree when we classify gangrene in this category.

(5) *New Tissue Formation.*—As the destructive effects of inflammation occur, so constructive work must be done to repair such damage. This is true to some extent in acute inflammation. The longer the process is prolonged, the more likely this termination and the greater the quantity of new (fibrous or cicatricial) tissue formed. The immediate result of an infection is to produce certain vascular and perivascular changes. The leukocytes deposited in and around the infected zone are aided, if the inflammation be subacute or chronic, by the formation of cicatricial tissue which serves to help the leukocytes in their effort to limit the spread of infection by building a permanent living wall around them. This artificial tissue may completely encyst the infection and limit it to that particular spot for indefinite periods, even for many years. In this instance the bacteria remain encysted and are so long harmless, but when by accident they become liberated from their encasement they rekindle their activity, possibly with rapid and fatal effect. In certain cases the new-formed fibrous tissue becomes calcified in part or throughout and effects permanent cure of the infection. This is seen in old inflamed lymph-nodes. The new-formed fibrous tissue may be no detriment to the organism, or, by its interference with important functions, produce the most direful results. So, where new tissue results from peritonitis, adhesions may impede peristalsis or cause intestinal obstruction; in the joints ankylosis, in the urinary bladder and gall-bladder contraction occurs, and the capacity of the organs is diminished until they will contain only a few drops of urine or bile. When cicatricial tissue forms from a diffuse inflammation of an organ the resultant contraction causes atrophy and diappearance of the stroma.

Long before any of the above terminations have had time to follow the infection which evoked the inflammatory process the patient may die of general intoxication, or, because of the very fact that the response to infection has been so extensive and intense as to suspend a vital function, death ensues while the inflammatory reaction is at its height. So in inflammation of the vital nerve-centers, in inflammation of the lungs, in inflammation of the kidneys, while the general condition may remain unimpaired directly by the infection, yet these organs, necessary to life, have their function suspended or so impaired as to render that function inadequate.

Signs and Symptoms of Inflammation.—Signs and symptoms of inflammation are divided into local and constitutional. The former are discussed first, being in a general way the more important of the two, inasmuch as they concern the process directly, although the constitutional symptoms offer a better index to the extent of the general impression, and may, when the site involved is deeply enough placed to render it inaccessible to observation of local signs, be the chief evidence for concluding that an inflammatory process is in action.

LOCAL SIGNS AND SYMPTOMS.—The local signs and symptoms of inflammation have come down to us from the days of the old Roman physicians practically without modification. They are five in number, heat, discoloration (redness), pain, swelling, and impaired function (*calor*, *rubor*, *dolor*, *tumor*, *functio læsa*).

(1) *Heat.*—In every inflamed region the temperature of the part is elevated somewhat above the corresponding part on the opposite side of the body, that is, is higher than it would be if the part were not inflamed. This statement is true regardless of the general body temperature, which may be normal, subnormal, or above normal. The abnormal temperature of the body, whether above or below normal, may be due to the infection causing the inflammatory reaction or to other causes; the relative temperature of the inflamed tissue maintains itself at a little higher point.

The increase of temperature may be recognized by the use of a surface thermometer, the part involved always being compared with its corresponding part on the opposite side of the body, hand with hand, right side of chest with left side of chest, thigh with thigh. If for any reason such comparison cannot be made, then the temperature over the inflamed region must be compared with the surrounding healthy tissues. The difference in temperature between inflamed and healthy tissues, if there be a fairly extended process, is perceptible to the hands applied upon them. In those cases in which the inflammatory process does not involve a surface the difference between healthy and diseased sides can still be detected, less marked, by the surface thermometer, if an extensive active inflammation be present.

(*a*) The cause of this local increase of heat is due chiefly to the increased amount of blood to the inflamed tissue, the blood in the internal organs being of higher temperature than at the surface, where its heat is constantly lost. The greater the quantity of blood brought into an inflammatory zone the higher the local temperature will rise, but it never exceeds the temperature of the internal blood at the time of observation.

(*b*) The increased chemic activity of inflammation was formerly though to be one of the chief causes of the local increase of temperature, but, as the limit seems to be the temperature of the internal blood, no great increase can be attributed to this source. It doubtless contributes a small part.

(*c*) *Diminished Radiation.*—When inflammation involves a cutaneous surface, a part of the increase in local temperature may be attributed to diminished radiation, due to disturbance of the skin glands and a consequent reduction in the quantity of moisture they liberate.

(2) *Discoloration or Redness.*—In all inflammatory changes the tissues affected become discolored by the increased quantity of blood present. It is usually spoken of as redness, and usually the color is red, but it is manifest that it may vary all the way from the brightest red of well-oxygenated blood to the darkest blue of venous blood. And this is an important index to the condition of the circulation of the part. If the color be cyanotic or purple, it signifies a much slower circulation, and indicates that sufficient blood is not passing through the vessels to take care of the infection. Just so in trauma without infection, the color of the tissues shows to what extent vascular damage has been wrought. Where such a condition obtains it is a sign of danger, and every effort should be enacted to increase the activity of the circulation. In trauma it presages gangrene or slough, in inflammation it means that tissue destruction is impending, whether gangrene or abscess.

Where the swelling is intense there may appear yellowish-pink areas over the surface, showing that the blood has been pressed out of the small vessels more or less completely by the swelling. This condition endangers the vitality of the tissues by depriving them of blood. Fortunately, these yellow spots are usually small.

Pressure on inflamed tissue forces the blood out of the vessels and renders the surface pale. Removal of that pressure allows a return of the color; the rate of the return is an index to the condition of the circulation. A rapid resumption of color showing active, a slow resumption showing poor, circulation. In tissues where the process has completely blocked the vessels, and thrombosis in the capillaries has occurred, pressure has little effect on the color.

(3) *Pain.*—As in many other diseased conditions, so in inflammation, pain is one of the most prominent, most deceptive, and most important symptoms. In the majority of inflammatory conditions it is this symptom that causes the patient to seek the physician's aid.

Pain is due in inflammation to the swelling and the toxins, and is produced by (*a*) stretching of the nerve-fibers; (*b*) pressure on the nerves or their endings; (*c*) irritation of the nerve-endings by bacterial poisons. The nerve tissue itself may become inflamed and contribute to the pain already present, but it does so in accordance with the three items above.

The study of pain, so vast in detail, so unsatisfactory in practical application, can be entered into here only in an elementary fashion. These fundamental points in connection with it will be laid down as a guide, and, it is hoped, as a stimulus to investigate more elaborately the more extensive works devoted exclusively to the subject.

Types of Inflammatory Pain.—The presence of an inflammation in various tissues and organs gives rise to very different types of pain. When a skin surface, or a mucous surface at or near the apertures of the body, such as nose, mouth, eye, vagina, urethra, and rectum, is inflamed the pain is itching or burning; it is sometimes scalding or tickling on the mucous surfaces, especially the latter in the upper air-passages and the former in the urethra. If inflammation attacks a serous surface, particularly the pleura or peritoneum, the pain is described as sharp, keen, cutting, stabbing, or lancinating; when inflammation of these surfaces is chronic, it is less likely to be sharp, except as acute exacerbations occur, and is usually described as dull, dragging, or aching. The remaining serous surfaces, namely, the synovial, do not show the intense keen pain so frequently, although it may be intense; it is more like the pains produced by inflammation of bone. Acute peritonitis and acute pleuritis offer the best illustration of this type of pain. In inflammation of the viscera, when their serous surfaces are not involved, the pain is described as dull, heavy, or aching in character. So the pain from a hepatitis or a nephritis or a pulmonitis is of this type, if, indeed, pain be present at all. An exception to this rule is found in acute pancreatitis, where the most violent cutting pains are felt, as in perforative peritonitis. When a viscus is inflamed primarily, and the serous covering becomes later involved by extension of the infection, the symptoms show the characteristic sharp pain of the latter. Example, a central pneumonia, later extending to the lung surface and involving the pleura. The pain produced in inflammation of bone, cartilage, and periosteum is of a dull aching or boring, gnawing nature and is usually worse at night (or, better, at the regular period of sleep). This is true whether the pain be due to acute or chronic inflammation, although the pain is necessarily more intense in the acute, other things being equal. Still an exception is found in syphilitic pains in the bones, essentially chronic, and almost invariably worse at night.

Throbbing pain is produced in inflammatory processes confined in more or less inelastic cavities or spaces. The exudate fills up the spare room, and as each systole of the heart drives more blood into the vessels it increases the pressure and exacerbates the pain. So each throb represents a heart-beat. This type of pain is observed in orchitis, certain subperiosteal inflammations, as whitlow, and in inflammation of the tooth-pulp.

Colicky or cramping, bearing down, or straining pains are found when the inflammation involves the lining of a hollow viscus. So in inflammation of the mucous membrane of the stomach, not only may the burning pain be present, but, at the same time, what is described as "stomach cramps." In inflammation of the mucous membrane of the intestine there may or may not be a burning sensation; in addition, a distinct griping or colic may be felt. In inflammation of the caudad extremity of the gut the griping is especially felt, and passes under the name of tenesmus, commonly spoken of as "straining," and is accompanied with an unsatisfied desire to empty the irritant from the bowel. In inflammation of the bladder and the deep urethra the "burning like fire" is accompanied by the straining to empty the bladder; the straining to dribble out a few unsatisfactory drops of urine is called strangury, and is of the same cramping nature as the tenesmus in rectal and sigmoidal inflammation.

Variations in the intensity of pain must be borne in mind, and the fact must never be forgotten that this variation may render our recognition of the true status valueless. One individual raves hysterically over an insignificant inflammatory process, and another tolerates with stoical silence the pain of a violent, extensive, and deadly inflammation. So the extent of complaint of pain must not be accepted solely as the measure of the pain and of the process producing it. The physician must use his utmost skill to read the degree of pain written on the facies, as he would read his thermometer; even now failure to appreciate the extent of the lesion may occur, for not only are the patients and pain variable, but certain extensive inflammatory processes are almost devoid of pain in regions where it is expected to be found. So that pain must be considered as but one of a group of correlated indices to the condition present.

Referred Pain.—The pain produced by inflammation may be felt at the site of the lesion, or it may be felt at some point more or less remote from the inflamed part. This latter is spoken of as referred, or reflected, pain. It is susceptible of explanation on anatomic grounds in certain instances; in others, on no hypothesis within the scope of our present knowledge. This reference of pain, found in other pathologic conditions besides inflammation, is sure to mislead the patient, and, unless the physician is constantly wary, he will fall victim to the same deception. Every pain of marked intensity or prolonged duration should be investigated for a cause, and no guess work is allowable until exhaustion of our diagnostic methods is made.

Referred pain is usually felt at some point in the distribution of a nerve-supplying tissue other than the part inflamed (this is probably due to stimuli short-circuiting from one nerve-fiber to others adjacent to it), or it may be referred to the distribution of another nerve whose center is closely associated with that of the nerve supplying the site of disease. Yet many times do we find referred pains affecting points remote from each other, not only from a physical standpoint, but remote in the sense that they have no peripheral or central nerve relationships so far as can be demonstrated. The rule is, that referred pains follow definite routes; however, this cannot be accepted as absolute. They may or may not be referred, and only a knowledge of the usual direction of reference can be entered into here.

Under the general subject of pain may be mentioned tenderness, which in certain inflammatory processes is of equal diagnostic value with pain; it enhances the value of pain as a diagnostic symptom. Every inflammatory process if acute, and usually if chronic, is tender; there are many painful conditions, non-inflammatory, which are not tender, but, on the other hand, are more or less relieved by pressure; therefore the observation of this tenderness becomes of the utmost value, especially in those inflammations which are situated so deep in the tissues as to show no surface signs. Often after the acute inflammation has subsided, and practically all of its immediate symptoms have vanished, tenderness remains as the sole index to the true nature of a past attack. For example, consider the tenderness remaining indefinitely after an attack of acute appendicitis or cholecystitis; in many cases it never disappears from one seizure to another. Again, in the subacute and chronic cases of the two above-named conditions, as well as in lesions of other structures, an obscure symptom or group of symptoms have tenderness as the most valuable guide to their proper interpretation.

Soreness is a second subhead under pain, which may yield faithful aid, especially when considered as a part of the case history. Pain may be present and at the same time violent; if due to inflammation, that pain will have tenderness associated with it; on subsidence of the acute symptoms, and disappearance of all pain and much of the tenderness, the region involved is described as remaining sore for several hours or days, whether elicited by active or passive movement of the parts. After an attack of intestinal colic, soreness does not persist when the spasm is off; but, if the pain is due to an inflammation such as acute appendicitis, then soreness often does persist. Soreness and tenderness cannot be accepted as pathognomonic symptoms any more than the remainder of the group, but their presence or absence should always be observed, since a true understanding can often not be had without them.

In inflammation of those structures capable of resulting disastrously, and that in a very short while, pain becomes not simply a diagnostic symptom, but, at the same time, is one of far-reaching prognostic value. Hence, no anodyne should be given internally until the diagnosis is clear enough to indicate a rational line of action, and the patient has agreed to the employment of safe means for his relief. The point is, sudden cessation of pain in an overdistended, inflamed viscus, such as the appendix, may mean either that the viscus has ruptured, poured its infected contents into the peritoneal cavity, or that it has become gangrenous and devoid of sensibility, a fatal turn in either instance, and one that, however the physician may have looked upon the case before, can now be viewed only in the light of an urgent surgical condition. If a large dose of morphin or other anodyne has been given and the pain relieved, it does not alter the process going on within, but hides from the physician valuable information which cannot be replaced until the opportune moment has passed. The same observation holds for other conditions, as we shall see.

(5) *Impaired Function.*—In every case of inflammation the function of the tissues or organs is disturbed in some way, either as an overactivity, or increased irritability, or as a reduction, in a true impairment of the function. In those organs which have two or more functions, such as the hollow viscera, the disturbance may seem to affect one function more than the others, but, since these functions are complements one to the other, the disturbance is recognized and spoken of as impaired function. For instance, one of the functions of a gut is to retain its contents sufficiently long to digest and absorb the nutriment contained therein, and the complementary function is that peristaltic contractions shall remove the detritus at a rather fixed rate. Thus, when the mucosa is inflamed, digestion is impeded or suspended, the retaining power of the gut is reduced far below normal in capacity, and the peristaltic motions are accelerated so that a diarrhea of varying intensity results. The former functions are reduced and the latter increased. Likewise, the urinary bladder, when inflamed, loses its power of serving efficiently as a reservoir, and must pass the few drops accumulating within it as rapidly as they are deposited from the urethral mouths; a dribbling, frequent urination is the consequence.

When the eye becomes inflamed its function is reduced to an extent that varies with the intensity of the process and with the part of the mechanism attacked. Of course, the eye can see, but it cannot perform accurately and constantly its function of seeing; in severe cases, the moment light strikes the retina a reflex blepharospasm is instituted and vision is a practical impossibility—the function of the eye is impaired.

In the case of articulations the function of a joint may remain in some degree, but its motion is always limited to some extent, often in some one direction more than in others; this restriction is positive, both in active and passive motions of the joint, and subsides when anesthesia or narcosis is produced, showing that it results directly from the process of inflammation and not from the gross changes interfering with the mechanism of the joint. The explanation of this phenomenon will be found a little further on, under the discussion of rigidity.

The vocal cords, when inflamed, cannot be made to produce voice, or, if they do, it is so altered as not to be recognized as belonging to its owner. Here the disturbance of function partakes of an additional etiologic factor, namely, that there is a thickening of the cords sufficient to change the quality of their notes or to render them silent.

The causes of impaired function in inflammation are very definite. They are, first, pain on function (sensory); second, fixation, if motion be a part of the function (reflex), due to involuntary rigidity or immobilization of the parts from refusal of the muscles to yield in their normal manner; third, interference by swelling or by other inflammatory products, such as exudate, lymph, and the resultant fibrous or osseous organic changes of the same (mechanical). These three factors may all interfere with function in a given case, or any one or two of them may be largely or wholly wanting. Pain may be responsible for impairing function by its continuous presence, whether function is attempted in the part or not; the fixation due to muscular contraction may be excessive, with relatively little pain, although the two seem to go fairly well together, the pain becoming violent and unbearable when attempt is made to overcome the muscular contraction. Yet in many cases, especially the subacute and chronic ones, the patient will complain of no pain until after rigidity of the muscles has attempted to check manipulation from carrying the motion to the painful point. This shows conclusively that the reflex immobilization is produced by other stimuli than pain. It is true, however, that this fixation always holds the part concerned in the position most comfortable to the patient.

Swelling need be discussed only briefly. It is manifestly an interference with the function of the parts affected, as in the vocal cords (*vide supra*), in the joints, in the mucous membrane, and the skin, where it cannot fail to alter the function of their glands. If an exudate be present and in considerable quantities, as happens in the serous cavities, then the functions interfered with may be not only that of the organ affected, but any and all those other structures in direct or indirect relation to the cavity containing said exudate, by virtue of its distention of this cavity and pressure upon such adjacent organs, causing their displacement or compressing them into limits too narrow for their normal behavior.

Permanent impairment of function may result from adhesions in serous cavities and their ultimate organization into fibrous, or, in the articular spaces, osseous tissue. The impairment in such instances persists after subsidence of all inflammation, and is of sufficient frequency to be guarded against as much as possible in all surgery of serous cavities.

Muscular Rigidity.—It is wise that in the study of inflammation attention be called to the extensive application of muscular rigidity in inflammatory processes, whether a disturbance of function of the inflamed structure is affected thereby or not. Mr. Hilton taught that the same nerve that supplies a muscle moving a joint sends also a filament to the joint and one to the skin covering the insertion of that muscle. So the joint mechanism is directly connected by nerve supply with every muscle that can move the joint. Hence, it is easy to understand how fixation of a joint may happen, and that independent of the patient's volition when the joint is inflamed. Similarly, it is easy to see that the fixation is brought about through centers in the cord, as the amount of pain suffered has little or nothing to do directly with the fixation. It is simply an associate symptom. This law of Hilton's has a far wider application now than when laid down by him. In inflammation of the peritoneum, especially if it is acute, the muscles of the abdomen become rigid, usually on the side affected and in the region affected, but, if the process be extensive or violent, the whole abdominal wall becomes board-like and respiration becomes thoracic, showing that the most important muscles of respiration have yielded to the demand for muscular rigidity. Thus, in cases of acute appendicitis, the right rectus and the right obliques and the transversalis become rigid. The more violent the attack, the more widely the rigidity extends from McBurney's point. It must not be lost sight of here that in certain intensely violent infections no rigidity is observed.

Again, in severe inflammation of the pleura rigidity of the respiratory muscles is found on the same side, and in inflammatory disease of the vertebræ the muscles moving them are affected likewise.

Fremitus.—While fremitus, recognized either by touch or hearing, is of value in only a few organs as a diagnostic sign, it is valuable enough when present to deserve special mention. In inflammation of the pleura, of the peritoneal covering of the liver, of the tendon sheaths (tenosynovitis), and of the articular surfaces of the movable joints a grating vibration can be detected when the diseased surfaces are rubbed over each other, as in respiration in the first two instances, and in active or passive motion of the parts in the last two. In arthritis the sign is so well developed as sometimes to mislead one into the belief that crepitus is present and that a fracture is the cause of it.

This fremitus must not be looked upon as a sign of inflammation *per se*, but rather as an accident of inflammation of the abovenamed structures. Here, however, it is of the utmost diagnostic importance, since by the usual signs of inflammation a diagnosis can often not be made with any degree of satisfaction; but, if suspicious signs present themselves and fremitus can be elicited, the diagnosis of inflammation is assured.

Similar special but indirect evidences are of great, of indispensable value in the recognition of obscure inflammatory processes, arising in many instances from disturbance of function; in others from evidences found in the secretions from the organ, in others from the presence and contents of exudates. Thus, we find the contents of the gastric juice altered materially in inflammation of the stomach and often a great excess of mucus. In inflammation of the mucous membrane of the intestine we find mucus, sometimes with the addition of pus and blood, in the feces together with undigested food. In case of pancreatitis its disturbed function may be recognized by the appearance in the stool of fats which have failed to be acted upon by the pancreatic ferments. In inflammation of the kidneys the alteration in quality and quantity of the urine, as well as the appearance of definite microscopic findings, shows the presence of nephritis often when no local or constitutional evidence has been observed. In meningitis the presence of an excess of cerebrospinal fluid, together with microscopic or cultural discovery of the causative infection, leads to a correct and unmistakable interpretation of symptoms whose nature rendered them most perplexing. Again, the appearance of jaundice, with little or no associate diagnostic symptomatology, leads to the knowledge that an infection is present in the biliary passages.

These accidental signs are so important, and so sure to occur in their special places, that no diagnosis of obscure conditions due to infection can be accepted as trustworthy until all the findings are passed upon. It is often necessary to repeat the investigation before the evidence sought can be found.

GENERAL OR CONSTITUTIONAL SYMPTOMS OF INFLAMMATION.—Inflammatory processes may be so limited or so mild as to produce no discoverable constitutional impression. They may be so extensive and intense as to overwhelm all the reactive and defensive powers of the body. They vary through all degrees between these extremes.

Fever.—Alteration of the body temperature is the most frequent constitutional symptom of inflammation, and the degree and direction of the change in temperature is a splendid index, in the usual infections, of the extent and danger of the infection.

Before discussing the subject further it is necessary to understand the significance of fever in a general way. Once considered an alarming condition, fever is now accepted as a part of the reaction of the body to the infective cause. And so, instead of being a symptom, to be combated as such, it is accepted as the most reliable index to the fight the body makes against invading bacteria. If, therefore, the temperature is reduced by artificial means, especially by depressing drugs, not only is the guide to the general condition lost, but actual interference with the formation of protective bodies may be produced. The rise of temperature in the presence of infection is due to the bacterial poisons distributed throughout the general circulation from the focus of infection. Increased chemic activity is produced by the presence of toxins in the blood, and reduced by removing the fluids or tissues whence absorption occurs; the temperature drops very soon after opening an abscess, cleaning out an infected uterus, or amputation of a gangrenous extremity. Just what rôle the heat centers play in the presence of poisons circulating in the blood is not known. Furthermore, the radiation of heat from the body surface, if not from the lungs, is reduced, so that the balance of a normal temperature can no longer be maintained.

The rise of temperature, then, in inflammation indicates the extent of the inflammation and the resistance of the patient. If the vitality be normal, then a reaction, in the form of fever ranging from a slight rise to 105° F. or more, may be seen, and it must be remembered that, even with this high degree, the fever is not to be looked upon as harmful in itself, but rather as a reaction to a harmful infection.

On the contrary, where the resistance of the patient is poor from disease or age, and the tissues are not able to react sufficiently against the poisons taken into the blood; where, too, the amount of poison is so great or its virulence so intense that the resistive powers are unable to cope with it, a subnormal temperature is observed and the outlook is grave. Those patients overwhelmed by overdosage of bacterial poisons suffer collapse, and, unless hasty removal of the focus and active and rapid elimination of the poisons is procured, death ensues shortly.

On withdrawal of the pus or other infected material from which the supply of poisons is drawn, the protective bodies of the blood and the organs of elimination soon dispose of the poisons remaining in the circulation, and the temperature drops to normal, at times accompanied by perspiration or diuresis, occasionally by a diarrhea. The fall to normal may be very gradual (lysis) or very rapid (crisis).

The fever arising from an ordinary pyogenic infection gaining entrance to a wound comes up in from eighteen to thirty-six hours subsequently. Inflammatory fever is then to be distinguished from postoperative fever or the so-called aseptic surgical fever. Postoperative fever usually follows the larger surgical procedures, and does not reach high grades, rarely rising higher than 100° to 101° F. It comes up within the first twelve to eighteen hours following the operation and subsides by the evening of the day following. Aseptic surgical fever is thought to be due to absorption of fibrin ferment from the wound surface, which, it is known, is capable of producing a rise of temperature when injected hypodermically; yet this rise of temperature probably is partially due to bacteria gaining admission to the wound in insufficient numbers to establish themselves and produce a local reaction. So, when a rise of temperature comes immediately after an operation and subsides by the end of twenty-four hours, it is accepted as of no consequence; when it comes at a time subsequently to this a search must be made for the cause, the first step being to investigate the wound.

Chill.—The surface of the body may seem cold to the patient, although his temperature is above normal. This may simply be a chillness, or it may be so marked as to be a distinct chill or rigor. The chillness may last for some hours or be very brief, and if a chill comes it may be, usually is, single, although it is sometimes repeated. There is usually an initial chill in certain types of inflammation, which is not repeated unless there is an extension of the infection, such as happens at times in erysipelas; when such extension occurs it is usually announced by a more or less distinct chill.

Associated with the fever of inflammation is the usual group of symptoms found in febrile conditions generally, the febrile syndrome. This includes malaise, pain in the back, and often in the extremities, headache, loss or diminution of appetite, constipation of varying degrees, unless the infection attacks the lining membrane of the intestine, when diarrhea may be present, and reduction in the quantity and increase in the color and the specific gravity of the urine. These symptoms, associated with an inflammatory fever, are not peculiar to it, but may happen in any fever, whether produced by pathogenic bacteria or not.

Pulse.—The pulse is accelerated in cases of inflammation, usually *pari passu* with the temperature. Yet there are exceptions of two kinds. In one instance the temperature may run exceedingly high and the pulse relatively slow, as is observed in inflammation of the lung produced by the diplococcus of pneumonia, where the pulse is full and bounding and slow, of the sthenic type, or in typhoid infection. On the other hand, we find cases of subnormal temperature with an extremely rapid and full pulse, observed in those ill-fated patients in whom the balance between the resistance and the infection cannot be maintained, and who are, therefore, overwhelmed by the virulent poisons in their circulation. The individual who has a high temperature and a slow (relatively) pulse may be accepted as offering splendid resistance so far, but the one with low temperature (subnormal) and a rapid and perhaps irregular pulse is to be accepted always as being in an alarming state.

Certain inflammatory processes tend to produce different qualities in the pulse, a fact of unmistakably positive value at times, but not worthy of rigid acceptance. As an illustration of this point, the slow, full, bounding pulse of lobar pneumonia may be given, or the small, rapid, hard, wiry, or thready pulse of acute peritonitis. Again, the weak, scarcely palpable, very rapid, perhaps dichrotic pulse, while belonging to no particular anatomic site, nevertheless warns the surgeon of impending dissolution.

The facies of patients suffering from severe inflammatory processes stand as the equal of pulse and temperature, if not their superior, as an index to the effect produced by the disease. There is no description worthy of the expression of the countenance of one violently intoxicated with bacterial poisons, but the evident rapid loss of weight, the pinched expression, the unnatural look, the pallid features, the cyanotic, livid lips, the leaky skin, the anxious, nervous, uneasy manner are tokens of illness which, when they have once been seen, cannot be forgotten and beggar all efforts at description.

In severe inflammatory processes, especially if they are of long duration, a distinct typhoid condition may be observed, with all the train of nervous and mental symptoms, developing subsultus tendinum, carphologia, coma vigil, stupor, delirium, coma, and death. Delirium may occur in acute cases of very short duration, as in other febrile conditions.

Leukocytosis.—The value of the leukocyte count as a diagnostic factor in acute inflammatory processes is well established, but cannot be looked upon as showing up in every case with sufficient preciseness to render it universally applicable. It must be accepted as of not only important diagnostic service, but as of prognostic importance. The rule is, that in acute inflammatory processes the leukocyte count often becomes the chief differential point between this condition and non-inflammatory processes. The increase may be so slight that it has no value, or the process in question may often be associated with another pathologic process which produces leukocytosis. Again, it may be influenced by the presence of diseases which habitually produce leukopenia, consequently an increase of 100 per cent. in the actual number may be observed without bringing the total count up to a maximum normal. In such cases, unless a series of counts are made at stated intervals, and unless the leukopenic process be recognized at the time, manifestly no importance could be attached to the findings. So in typhoid fever, with its usual leukopenia, an acute inflammatory process may develop, and at no time raise the count above normal for a healthy individual. However, if the count be made every hour or two from the time of the suspected inflammation, and the alteration of the leukocyte count from hour to hour noted, relatively great variations may be found. In acute inflammations the range of leukocytosis may run all the way from a worthless increase of a few hundred cells to two or five times the normal, and present such a differential picture that it may be accepted as almost pathognomonic, even when apparently strongly contradicted by signs and symptoms. Leukocyte counts which do not consider the differential percentages cannot be relied upon implicitly for diagnosis, and have no prognostic value. However, if the differential count can be made by a competent microscopist it gives valuable diagnostic and prognostic information; in many instances the count, on the other hand, is of little or no value.

Gibson's Chart.—Consider the normal number of leukocytes as 10,000, and the normal percentage of polymorphonuclear neutrophiles as 75 per cent., both admittedly high maximums, there seems to be a normal ratio maintained between the count increase and the percentage increase. A marked variation from this ratio indicates inability on the part of the body to cope with the bacteria causing the demand. The ratio maintained with greatest advantage to the patient, according to Gibson, is that each increase of 1000 in the total count should be accompanied by an increase of 1 in the percentage. Thus, with a total count of 20,000 the polymorphonuclears should be about 85 per cent. The polymorphonuclears are the phagocytic, the anti-infection cells. If the percentage is high and the total count low, it is interpreted to mean that the demand is very great or that the patient's resistance is poor. A paradoxic fact is at times found, in that a very limited inflammation may be seen with a very marked leukocytosis, and, *vice versâ*, a very extensive process with slight leukocytic disturbances. This may be at least partially explained by the relationship existing between the resistance of the tissues and the virulence of the infection. One can but say, in justice to the subject, that, while of the utmost importance as one symptom of acute inflammation, the blood count cannot be relied upon as an unfailing procedure. Acute inflammation has been specified advisedly in this discussion, for it seems so far that the leukocyte findings are of little value in chronic processes.

One exception deserves to be made to the above rule for the significance of the total and differential counts. In cases of abscess of the spleen the total count is reduced far below normal and the lymphocytes constitute the majority of the cells. Further, in those cases where an inflammation is present, and shows the characteristic leukocyte changes, if a secondary involvement of the spleen results, the same leukocyte picture follows as if the splenic infection were primary (Eppinger).

Diagnosis of Inflammation.—As a superficial process inflammation may usually be recognized without difficulty. But when situated deeply it often becomes a veritable impossibility to clear away the obscurity hovering over the nature of the lesion. The conditions causing confusion are numerous—special affections obtain for the various organs. In general, tumors, cysts, and the so-called granulomata are among the frequent causes of uncertainty. Many individuals are unable to give a definite history of such conditions, and the diagnosis is thereby made more difficult; especially is it difficult to penetrate the obscurity in these cases when an acute inflammation has developed on such pre-existing growths. Again, in the case of many constitutional conditions it is difficult to determine whether the symptoms arise from an obscure inflammatory process. Frequently the only method for settling such uncertainty is to await the appearance of diagnostic symptoms. The differentiation of acute non-inflammatory painful processes in the abdomen, thorax, and cranium often present extreme difficulty, especially if a rise of temperature is accidentally or consequentially associated with them. Hence, many acute intra-abdominal lesions, intestinal obstruction, crises, enterospasm, and neuraliga, together with the painful conditions growing out of intra-intestinal conditions, present such insurmountable and alarming symptoms that a timely interpretation of the case can be given only by exploratory section. In the thorax, aneurysm and tumors may cause hesitancy in eliminating inflammatory lesions and a pleurodynia may not be distinguishable from pleurisy, if the characteristic friction sound be obscured by adhesions or other causes. In the cranium and spinal column the differentiation must be made between affections within and those without the respective cavities, and between inflammation, on the one hand, and tumors, cysts, hemorrhages, aneurysms, thromboses, emboli, and depressions on the other.

It is safe to think of inflammation whenever an obscure lesion becomes evident, and in most instances sufficient evidence can be had, either by discovery of local signs, of constitutional symptoms, or of disturbance of function, sensory, motor, or secretory, to unravel the mystery, or the failure of these will eliminate inflammation from the question entirely. In spite of all, now and then a just conclusion can only be reached after all known means are in a given case exhausted, and far too often no accurate conclusion is made until the postmortem unshrouds the mystery that has destroyed another life.

Prognosis of Inflammation.—The prognosis of inflammatory processes depends on several factors. As the preceding pages have taught, it depends first on the virulence or the nature of the infection and the resistance of the patient. The same poor protective powers of a body that have been unable to ward off or stamp out an infection in its incipiency may succumb to the spread of that infection in its tissues. A slight infection of virulent bacteria may thus destroy tissues or life in one who in a better state of health might have suffered no inconvenience from it. The quantity of the infection often plays a prominent rôle in determining the result. It may be said of the pyogenic cocci that for the normal individual there is a maximum dose which can be overcome by him without signs of inflammation, and that all degrees of reaction will follow doses in excess of this maximum until so great a number of bacteria are administered that the resisting powers are overwhelmed and prostration and death follow in a few hours. Therefore in those cases where a large abscess discharges its contents into a cavity of great absorptive capacity, such as the peritoneum, or when a hollow viscus ruptures and pours its bacteria-laden fluids into it, it will be easily understood why the exitus is so rapid.

The general resistance of the individual is not the only item of importance in this connection. In practical work local conditions often arise as the result of accident or of surgical procedures which reduce the local resistance far below the general, and, by making it possible for bacteria to gain a footing in this unresisting tissue, establish an infection which gives rise to very serious consequences. Especially is this local diminution of the protective power found in those cases where the main blood-supply is reduced to a minimum by ligation or by trauma.

The prognosis again depends on the importance of the organ or tissue affected in maintaining life, and on the possibility of complications arising directly or indirectly from such a process. The more vital the structure affected, naturally, the more untoward the outlook, so that all inflammatory processes affecting the heart, lungs, central nervous system, and kidneys are capable of very rapidly terminating life. A process which in muscle or bone might spread widely with only temporary discomfort would in a vital organ or center produce very early death. It can be seen readily, too, that if the inflammation is so situated that by pressure of the swelling it could affect these organs the same result would follow; if a thrombus should form from a facial inflammation and extend into the sinuses of the skull, or if it should form from proximity to an extracranial infection, as in mastoiditis, it becomes a serious menace to life. If in the course of the circulatory system the inflammatory process should result in the formation of vegetations, as in endocarditis, or in thrombus formation in a comparatively safe region, as in the femoral vein, the fact that these clots and vegetations may at any moment become dislodged and complicate a curable inflammatory process by a fatal embolus renders the danger much more apparent.

Treatment of Inflammation.—The treatment of inflammation, to be efficient, must be applied in harmony with the efforts undertaken by the inflammatory reaction, as set forth in the definition at the beginning of this discussion. It must also embrace in certain cases the relief of pain and such general treatment as the remote action of the infection may demand. Then all therapy directed against inflammation (it would be wiser to say infection) must be such that it will assist the inflammatory process in its good efforts at the prevention of such deleterious action and complications as grow out of the process in a given structure; it must eliminate the bacteria, prevent their action, and spread and repair the damage done by them, or remove the destroyed or dangerous tissues completely from the field; it must eliminate all factors favoring the continuance of infection. Since these ends are undertaken by the tissues, and since the chief means of action is by the protective powers of the circulating fluids, all remedial interference must re-establish the circulation as well as possible by active or passive means, and must bring these protective fluids to and maintain them at their highest efficiency. Where experience has shown that this cannot be done satisfactorily, and where, by such a course of action, the subsequent complications or the recurrence of attacks show that ultimate cure cannot be done, the surgeon may do at a single treatment all that is attempted by milder methods, namely, a removal of the offending tissue.

The treatment of inflammation is local and constitutional.

LOCAL TREATMENT.—*Removal of Cause.*—The first and, theoretically, most essential item of local treatment of inflammation is the removal of the cause, namely, the offending bacteria. Out of this necessity grew the extensive use of antiseptics in the treatment of such conditions. However, this treatment has fallen largely into disuse, since it has been learned that the antiseptics do not reach far beyond the surface to which they are applied, and hence, if beneficial, they are so by some other virtue than that of antisepsis. The good derived from such treatment is chiefly due to the counterirritant property of the antiseptic used, or to the serviceable effect of the heat or cold of the solution containing it. Aluminum acetate and carbolic acid solutions have been used extensively, and iodin, alcohol, and ichthyol have been used, but it is doubtful if a case could be made out for any of them as giving relief by its antiseptic action in an established inflammation, except in the case of ichthyol in erysipelas, where it seems to give apparently good results; how, we do not know. The only cases where antiseptics as such seem to cure by destruction of bacteria is where they are injected into the tissues. The chief instances of this are found in the occasional abortive treatment of a beginning abscess by injection of carbolic acid and the injection of formalin solutions into the pleural and articular cavities. Whether they serve in these cases by their antiseptic power exclusively is very doubtful.

Rest.—This term applies not only to rest of the part affected, but if the process is extensive or dangerous, or if it affects very important organs, it must be applied to the body as a whole. It is in this sense a part of the general or constitutional treatment, but for conciseness is given here.

It is well known that the blood-pressure is higher and the circulation (the number of heart-beats) is more active during even moderate exercise than when standing or sitting, and in these attitudes it is more active than when the body is recumbent. Interpreted, this simply means that the blood is being forced unnecessarily against the already stagnant cells in the field of inflammation, and so renders the condition less capable of taking care of itself. If, by reducing the activity of the body—that is, by rest—the number of pulsations can be reduced to a minimum, and unnecessary work so removed from the heart, a distinct local advantage will be gained, and vitality that will possibly be needed in the course of the disease will be conserved. On the contrary, if the inflammation is of the asthenic type, the increased activity, though not affecting the local process, will so draw upon the poor reserve of vitality as to prove an unquestioned, perhaps fatal, loss. Therefore in cases of acute inflammation it is safe to say that rest, if possible in the recumbent position, should be enjoined, and that this should be accompanied by prohibition of mental activity, such as the attendance on business or the visits of friends, and the prevention of exciting news, inasmuch as they all tend to increase the activity of the nervous system and draw on the resistive powers. In many cases of chronic inflammation rest in bed is not advisable, and may even prove positively harmful. So, for example, no one prefers to order such for a case of tuberculous synovitis or osteomyelitis longer than the circumstances absolutely demand. In these exactly the opposite obtains—bodily exercise, with necessary conservation of the diseased structure, the association of friends, fresh air, and cheerfulness serve a good purpose.

Rest of the diseased organ, local rest, is likewise one of the most indispensible items of the local treatment. It must be physical and as much as possible physiologic rest. The patient must not use the part himself, nor must outside influences be brought into action, so as to interfere with the reparative work going on. An illustration of passive disturbance of an inflamed field is seen in the antiquated method of squeezing an inflamed tissue in an effort to force pus from it, or in undue instrumentation of an inflamed area, as the bladder or rectum, or needlessly frequent application of treatments that are at least of questionable importance. When an eye is inflamed it should be placed at rest by preventing the performance of its function of vision by prohibiting the use of the eye, and should have enforced prevention of its accidental use by covering it with an opaque dressing or by confinement in darkness. When the larynx becomes inflamed silence must be insisted upon if the most speedy recovery is expected. This has recently been emphasized by the announcement of cure in several cases of tubercular laryngitis by tracheotomy. When the stomach becomes inflamed it is given rest by withholding food and substituting artificial feeding, or, if food is allowed to enter it, it is given in small quantities of fluids of the most nutritious kind, thus gaining the greatest benefit from the food with the smallest exertion of the stomach. In cystitis the bladder is drained by a self-retaining catheter or by cystotomy, and thus the two functions of that viscus, namely, retention of urine for a time and its periodic evacuation, are both eliminated. In acute peritonitis nature attempts to hold the continuously moving intestine in abeyance by rigidity of the abdominal muscles, and this effort at enforced rest should not be thwarted by the administration of a purgative, which, if it proves able to produce peristalsis, will serve only to scatter the infection broadcast or to force additional intestinal contents into the peritoneal cavity if a perforation is present. In a similar way acute inflammation of the joints is splinted by nature, and meddlesome activity in efforts to manipulate the joint prove not only of no value, but are capable of much harm. The body as a whole must rest, and the part affected must rest in cases of acute inflammation.

If the inflammatory process is chronic, then the nature of the case must determine whether bodily rest in bed is useful. Local rest is useful to a certain degree, but must not be carried too far unless adhesions are accepted as preferable or inevitable. Passive rest is not commendable in chronic inflammations, certainly not in all, for manipulation and massage hasten the recovery and diminish the chances of untoward sequelæ.

A single additional statement is necessary—after the termination of an acute inflammation the return to normal function must be guarded lest a recurrence follow. It is better to permit gradual resumption of activity than to allow it to be sudden and complete.

Position: Elevation.—The impaired circulation of inflamed tissue is influenced by elements that have no bearing on healthy structures. The demand for a free circulation, the freest possible, is the chief local need in an inflammatory process, and, while the circulatory apparatus is able to handle the return current of blood from the most dependent parts of the normal body fairly well, the least interference by gravity with the venous return from an inflamed structure is perceptible to the patient by the increase of pain and retards recovery, or actually serves to cause a severer termination of the process than would otherwise occur. The same is true of artificial obstructions, such as garters, tight clothing, or bandages on the proximal side of the lesion, or of pathologic interference, such as thrombosis of an important vein and tumors pressing upon the vein. Hence, the dependent position of an inflamed organ is to be avoided as much as possible, and elevation sufficient to maintain an easy return of the venous blood is to be made. So if the foot is affected, the best results are had by lying in bed and placing the foot on a rest above the level of the body, comparatively moderate benefit only being derived from sitting with the foot on a level with or a little above the buttocks. So carrying the hand in a sling is better than allowing it to hang by the side, but not so good as elevation to or above the level of the shoulder.

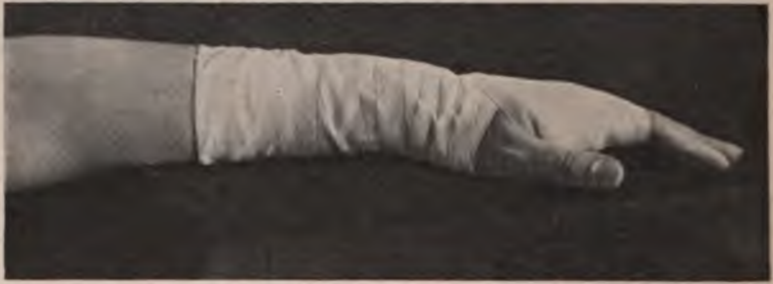

Fig. 14.—Forearm and hand resting in elevated position. Treatment of inflammation.

Another application of position demanding consideration, and imperative in practice, is that where an inflammatory process has resulted in an accumulation of a discharge, whether serum or pus, and a vent for the same has been established, the position must be such as to insure the freest and easiest discharge of the fluids.

Compression.—Pressure, or compression, may become a useful adjuvant in the treatment of inflammation. Support would probably be a better term than either of the above, for the pressure is always to be applied guardedly. Pressure should be uniform in its distribution over the surface affected, and is accomplished by applying the bandages with uniform tension—it is difficult to wrap them so that one edge does not bind more than the other. Compression is more valuable in subacute and chronic inflammation and in the resolution of acute inflammation than during the early stages of the latter; for, if a bandage be firmly applied early, and the swelling continues, severe damage may be done before the dressing is recognized as the cause. In the early stages of inflammation the tight bandage can do no good and is capable of great harm. But in those cases where there is great swelling and edema, and where the process has passed its height, a hastier return to normal is obtained by using compression. In cases where the process is subacute or chronic the application of firm compression is very beneficial; this statement holds true for synovitis, with accumulation of fluid in the joint cavity, as well as elsewhere. Compression has proved very widely useful in the treatment of epididymitis after the subsidence of acute symptoms. It is usually accomplished here by the application of an adhesive dressing. As soon as the dressing becomes loose by subsidence of the swelling under pressure it should be reapplied.

Local Blood-letting.—By the term "local blood-letting" is meant the withdrawal of blood from the affected region without any attempt to impress the general circulation thereby and thus indirectly to affect the inflammatory process, but to produce an immediate and direct effect on the tissues concerned. This method of treatment, when properly employed, affords one of the most useful, grateful, and rational means of relief. The result is accomplished by allowing a discharge of blood and serum directly from the painful, throbbing, swollen part. This escape of fluids relieves tension more than temporarily, reduces or allays the pain; the fluids carry out with them a portion, perhaps insignificant, of the bacteria, and somewhat of the toxins; this relieves the engorgement in the vessels and the pressure from those not affected, and allows resumption of a more active circulation and the entrance into the field of action of fresh leukocytes and serum ready to combat the remaining bacteria. Not only so, the continued flow of serum in greater or lesser quantity from the openings made guarantees the maintenance of a fresh supply of antibacterial substances for some hours.

There are four methods in use for this purpose:

(*a*) *Scarification.*—This method of local blood-letting is of service in limited inflammations of the mucous membranes, and could manifestly be of little usefulness in extensive processes. The epithelial covering is cut through at several points with a scarification knife, with as little trauma to the underlying tissues as possible.

(*b*) *Multiple Puncture.*—A sharp bistoury is employed here, and several punctures are made down into the inflammatory mass, reaching as deeply as the case may demand. This method is intended to allow an escape of fluids from the depths of the process.

(*c*) *Incision.*—If the preceding method for any reason seems inadequate, incision, single or multiple, parallel or crucial, is done deep down into the inflamed tissues and a large outlet is made.

(*d*) *Leeches.*—This is mentioned more as a matter of completeness that from any desire on the author's part to recommend it. Yet there are patients who will submit to leeching, though positively refusing either of the two preceding methods. The objection to the use of leeches is that they are gruesome, presumably not aseptic, and at times troublesome to handle. Still there are recent texts by able authors recommending their use.

In employing any of these methods asepsis is, of course, imperative. If one desires the bleeding to continue for a time, it is accomplished by the use of tepid water on the bleeding surface or by the employment of a dry cup. When it becomes necessary to control the active hemorrhage a pack or compress and hot water will be sufficient. If the inflammation is produced by anaërobic bacteria incision is of utmost importance, as it serves the purpose of treating the inflammation and crippling the bacteria by admission of oxygen at the same time.

In the employment of local blood-letting surgery has its most certain means of aborting an inflammation and of preventing the more undesirable terminations. The course of the inflammation is certain to be curtailed by it and the ultimate tissue destruction will be prevented or materially limited.

Heat and Cold.—The use of heat or cold, especially the former, has long been a favorite treatment for inflammation. They may be used as dry heat or cold and as moist or wet. The latter method has been thought the more advantageous, on account of the shriveling effect of prolonged exposure of cutaneous surfaces to water, the appearance of the washerwoman's hands after several hours' service at the tub being cited as an illustration of this power. In the light of our knowledge of the *modus operandi* of thermal treatment, it would seem indifferent whether the application is dry or moist, and the only advantage of choice between the two is convenience of application. The use of poultices, so universal a few years ago, had as its chief recommendation the heat contained in them and their tendency to retain it a considerable time; and did not, as was thought, depend on any therapeutic value in bran, slippery-elm, peach-tree leaves, flaxseed, and so on. No fault could even now be found with the essential workings of treatment by poultice in certain cases, but they are filthy and uncomfortable, and are not only not sterile, as a rule (some were shockingly nasty), but are favorable pabulum for bacteria. Some of the modern poultice material found in the markets has the same advantage of making a moist dressing, and can be used either hot or cold. About the only advantage gained by the drugs contained in them is to render and keep them sterile. But all forms of poultices are to be viewed as means for applying moist heat or cold, nothing more, and this can be done in a simpler, more convenient, and cleanlier way by the use of packs, compresses, or towels which have been saturated with water, or by allowing the water to run over or by immersing the part in water.

If dry thermal treatment is desired, the water-bottle, coils of tubing through which the water flows, or the thermophore are the most convenient means of application. In the administration of cold in rubber, glass, or metal vessels it is best to have a covering of cloth, or to place a towel between the receptacle and the skin, as condensation on the surface dampens the skin and the clothing. It is wiser in cases which are likely to need surgical work at any moment to employ only dry heat or cold, as the prolonged maceration of the tissues would render asepsis more difficult of accomplishment. Another method of administering heat is the hot-air chamber; this can be used in those cases where the parts can be enclosed in the apparatus. In this method of employing heat the temperature may be brought to very high limits without harm. It is chiefly useful in chronic inflammation of joints.

Heat and cold do not produce their therapeutic effect in a mechanical way, for, while they possibly dilate and contract the blood-vessels much as they do metal tubes, their chief action is reflex through the vasodilators and vasoconstrictors, and their direct action is negligible. This is mentioned to emphasize that it is not the application of violent heat or cold to the tissues that is necessary, but the prolonged application of tolerable degrees. In case of heat there is little danger, except in unconscious patients; conscious ones will complain of excesses. But in the use of cold, with its anesthetic tendency, great harm may be done by temperatures below that of melting ice. It must be remembered that the temperature of ice, if gathered fresh in the winter season, may be very much below the freezing point. To state the facts tritely, the object should be not to cook the parts or to freeze them, but to stimulate the circulation reflexly into greater activity, and moderate degrees of heat and cold are sufficient.

When to employ heat and when cold is a difficult problem, if, indeed, there is a choice generally, except in so far as the comfort afforded may determine it. Some surgeons use heat and cold alternately, applying heat for an hour or two and cold for a similar period. Since cold contracts the blood-vessels, it would seem to be indicated in those stages of inflammation prior to stasis, and since heat dilates the vessels, it would seem preferable during the latter period of congestion and during stasis. But in every inflammation these stages exist side by side, and so no choice could be made on such a basis, except it be the alternation of the two. In most cases heat is preferred, but in acute inflammation of the peritoneal cavity and of the testicle and epididymis cold is usually preferred.

Heat or cold may be applied continuously or at intervals, an hour or two on and an equal time off.

The use of heat in acute inflammatory processes about to suppurate hastens the breaking down of necrotic tissue by its favorable action on bacteria in areas where the circulation has ceased, and limits the inflammatory process in the surrounding zone by stimulating the circulation to greater activity. In tissues whose circulation is maintained it is inconceivable that the activity of bacteria could be materially increased by its application.

The danger in the use of heat is a burn; in the use of cold there is danger of causing death of tissue by prolonged application, especially in the very young and the very old and feeble.

Counterirritation.—This method has been employed in the treatment of inflammation for ages, and its value depends upon the increased flow of blood to the region affected. Its usefulness is chiefly in chronic and subacute inflammatory processes, although it is employed in certain acute processes with apparent benefit. Acute conditions in which counterirritation is used are pleurisy, lobar pneumonia under certain circumstances, and inflammations of the mucous membrane. One would not think, however, of employing it with advantage in hyperacute or fulminating cases in any tissue.

Counterirritation is made by the application of rubefacients, as illustrated by bathing the part in mustard water, or by the application of mustard plasters, by rubbing with turpentine or some irritating liniment; by the application of iodin in some form, the usual method, as tincture of iodin, compound iodin ointment; by the use of other ointments, such as ointment of the nitrate of mercury; by blistering agents, as cantharides, cantharidal collodion, and other similarly acting drugs; and by the employment of the actual cautery to produce multiple flying blisters. The application of the cautery is made at points ½ to 1 inch apart, and over a relatively wide area. No dressing is necessary except simply covering the field with dry sterile gauze, and even this is dispensable. The application of medicaments to soothe the pain following is contra-indicated. After a few days, when scabs have formed and are falling off, or after the blisters are dried up, a second application may be made, if necessary, touching the skin in the intervals left from the preceding sitting. It is probably wiser to do such treatment without employment of anesthesia, for, if one admits that the therapeutic effect is the same, still some importance must be attached to the mental effect produced by such treatment. It is useless in all cases where necrosis or suppuration has occurred, and finds its best field in deep inflammations, such as periostitis, synovitis, arthritis, and inflammatory processes in the muscles or ligaments of the back.

Counterirritation, carried to the extent of producing large blisters, has the additional effect of withdrawing considerable quantities of fluid from the blood.

The so-called resolvent drugs have probably no effect beyond that of mild counterirritation. Those drugs which are mixed with counterirritants are intended to produce some adjuvant effect —aconite and iodin are used, and aconite, iodin, and opium are used in combination to dilate the vessels and to allay pain. The cooling lotions, once very extensively in vogue, had the same effect as the employment of moderate cold.

Massage.—In acute inflammation massage must be accepted as having only a harmful effect. The more acute the process the more peremptorily is it contra-indicated, for the reasons assigned under Rest. However, after the acute stages have passed, and in subacute and chronic inflammation, it has very decided usefulness. Massage stimulates the circulation, breaks up new-formed tissue and encourages its absorption, and prevents thereby sequelæ in the nature of adhesions or ankylosis. It is of greater value when used in conjunction with counterirritation, or with the application of moist heat by immersion of the part in water heated to tolerance, and the performance of massage during or immediately subsequent to the immersion. Massage may be accompanied by a certain amount of physiologic use of the part, which accomplishes the same end, and directs the result along useful lines. So, for example, in inflammations of the hand the resulting stiffness may be overcome by the persevering practice of the patient in squeezing a hollow rubber ball. In the after-treatment of adhesions following extensive peritonitis the constant stimulation of peristalsis by the use of laxatives is nothing more than a physiologic massage of the intestines, and the constant traction and rubbing of the adhesions not only lengthens them, but causes their absorption, so that in subsequent laparotomies a surprisingly small vestige of some former violent and extensive peritoneal infection, with its great outpour of lymph, is observed.

Hygroscopic Drugs.—If an inflammation is on or near a mucous membrane the local application of hygroscopic drugs is of decided value. The special field of usefulness for this class is in the treatment of inflammation of the organs of the female pelvis by vaginal tamponade. The drug most widely used is glycerin, usually containing an admixture of boroglycerid or ichthyol. By the use of this treatment fluids are drawn from the region, and subsequent improvement may be expected; it depletes the parts.

Bier's Hyperemic Treatment.—Under the name of hyperemic treatment Bier has grouped a number of older methods of treatment of inflammation, elaborated them, added much that is new, and given the reasons for the success of the methods which have become the explanation of the success of other treatments; he has shown that it is by bringing leukocytes and fresh serum to the diseased tissue that a cure is brought about. In other words, he practises artificially as close an imitation as possible of what nature undertakes in the relief of inflammation. It is of necessity true that all successful methods for treating inflammation accomplish their end by bringing the antibacterial properties of the tissues into play. In untreated inflammation they are delivered by the circulation (active hyperemia): they are delivered in increased proportions under the influence of heat, cold, counterirritations, massage, and position, because of the ability of these methods to stimulate the circulation, favorably modify the lumina of the vessels, or reduce the resistance to blood circulation by facilitating venous return. The same end is accomplished in Bier's method. In the cure of inflammation, not only must the bacteria be eliminated and the tissues returned to their normal state, but the toxins, which are more abundant at the site of infection than elsewhere, must be disposed of. Since these bacterial poisons produce the constitutional symptoms present, it becomes evident that there are certain conditions under which it would be unwise to produce passive hyperemia; and, after overfilling the tissues with blood and serum suddenly, to turn this fluid again into the general circulation, since the general resistance would not be able to cope with the increased quantity of toxins whatever the fate of the bacteria which produced them might be. So many toxins may be turned into the circulation as to produce a fatal result, even though all bacteria might be destroyed. This is one danger to be guarded against in passive hyperemia. Again, when the tissues are swollen to the limit, and when there is evidence of impending necrosis, one can see how passive hyperemia of slight degree and of short duration would tend to hasten, if not positively determine, gangrene of the part. Hence, if Bier's treatment is to be applied in cases of infec-

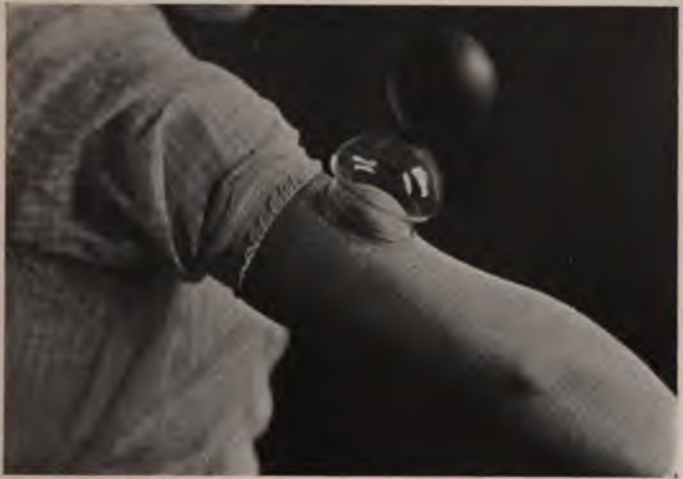

Fig. 15.—Bier's hyperemic treatment—cupping.

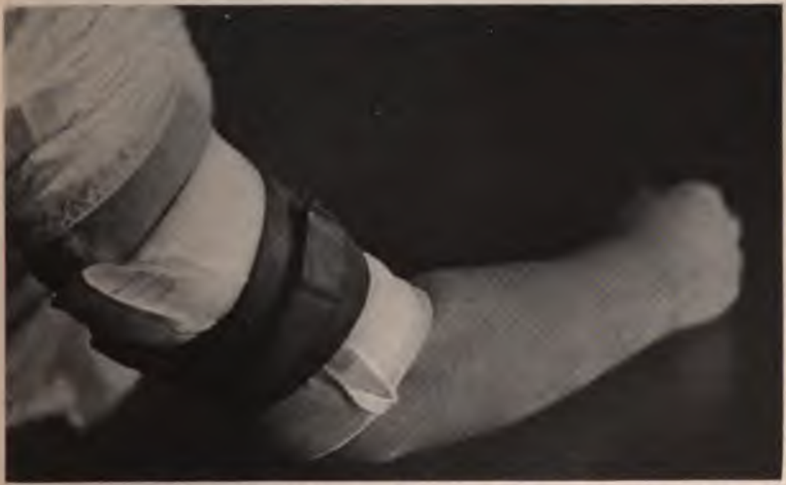

Fig. 16.—Bier's hyperemic treatment—tourniquet.

tion which present general symptoms of high toxicity, or in those where a dissolution of the tissues is imminent, the treatment should be administered either not at all or with the utmost caution, or should be preceded by incision of the parts, so that an escape of the accumulating toxin-laden fluids may take place almost as rapidly as they accumulate, thus giving in an intensified manner the same results already seen from local blood-letting.

The methods suggested by Bier for producing hyperemia are negative pressure or cupping, obstruction of the venous return by compression with circular bandages or tourniquets, both producing passive hyperemia, and the application of heat, as in hot-air chambers (active hyperemia).

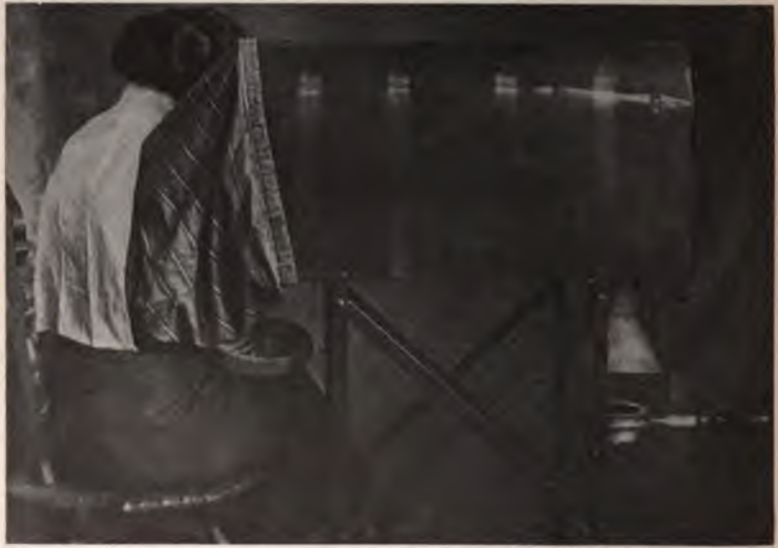

Fig. 17.—Bier's hyperemic treatment—hot-air cabinet.

The duration of each treatment, the frequency of treatment, and the extent of pressure used vary with the conditions present. The treatment by passive hyperemia may be given in sittings of from one-half hour to twenty hours per day. In the acute cases the sittings are relatively longer, while they are shorter in the chronic processes. It is necessary to release the pressure at intervals, allowing a rest of a few minutes between. Thus, in a case of acute superficial abscess forty-five minutes daily may be consumed, applying the cup, retaining it five minutes, remove it, rest three minutes, reapply, and so on. Treatment may be made daily, twice daily, or every other day, as the case may be. Hot-air hyperemia (active) is more useful in chronic inflammatory processes and in cases where considerable exudate remains to be absorbed.

Local Anodynes.—When the pain persists, in spite of the treatment of inflammation as outlined above, all of which should tend to alleviate the pain, it becomes necessary to resort to drugs for relief. These, however, should not displace the curative treatment, which should be tried faithfully, if possible, before resort is had to anodynes, for usually the employment of rest, elevation, heat or cold, and local blood-letting will give sufficient relief to render the use of anodynes superfluous. When, owing to the location of the inflammation or for other reasons, the pain persists or increases, no hesitance need be had in attempting relief by topical applications. The drugs of most efficient service are opium and its derivatives, belladonna, frequently used in combination with the former drug, and tincture of conium. Cocain is also highly efficacious, but it must be remembered that habit of this drug is quite as frequent by local as by hypodermic or internal administration, and that the beginning of most cases is a physician's prescription. The use of laudanum and belladonna may give satisfactory results by application to an inflamed skin surface, but the most beneficial results are obtained by applying them to mucous membrane. The special region where pain is most satisfactorily relieved by belladonna and opium is in inflammations of the rectum and anus, and in the deep urethra and the base and neck of the bladder, in which region they are administered with most grateful comfort to the patient. They are to be administered here in the form of suppositories.

There is still another drug recently come into repute as not only a relief for the pain of inflammation, but as a curative treatment, namely, magnesium sulphate. It is employed in superficial infections, and is applied in saturated solution, which is poured on the dressing sufficiently to keep it wet. The pain is mitigated, often to the extent of comfort, and the inflammation is shortened, and complications and untoward terminations are less likely to occur. Manifestly, it would be of no service in lesions widely separated from the surfaces of application.

GENERAL OR CONSTITUTIONAL TREATMENT OF INFLAMMATION.—(*a*) *Increase of elimination* may be taken as the first step in the constitutional treatment. The secretory and excretory organs must be brought to their greatest efficiency. The administration of purgatives, of diuretics, and the production of diaphoresis are the three lines along which we may work. There will result, not only an elimination of harmful products, but the organs of the body will be placed at the greatest advantage in the performance of their nutritive function. There is no need to undertake elimination by all three routes, but, under ordinary circumstances, the alimentary tract and the kidneys are impressed into extra service. A purgative is given, and large quantities of water are administered; hot water is a more serviceable diuretic. If for good reason any one of these three routes cannot be safely stimulated to higher activity, or if it is necessary to relieve it of as much work as possible, the other two may be used. So in cases where the peritoneum is inflamed, purgatives will disturb the rest of the tissues, and, by exciting peristalsis, will intensify the inflammatory process. Hence, the kidneys and the skin only of the three methods may be employed in these cases. If the inflammation affects the mucous membrane of the stomach or intestine, then vomiting or purgation at the beginning is necessary to remove the contents and afford rest. If the inflammation is in the kidneys, their work must be undertaken by the skin and bowels, but, under no circumstances, by attempting to drive the kidneys to perform excessive work in their crippled condition. The physician is easily at a disadvantage when one of the eliminative organs is crippled by the disease he is attempting to treat.

(*b*) *Increase in the General Resistance.*—The bodily vigor should be brought to and maintained at its highest efficiency. Hence the food, both in quantity and quality, must be such as to accomplish the end desired without undue or unnecessary exaggeration of any symptom. Where the sufferer is in poor health, anemic, and emaciated—*i. e.*, in the asthenic type—the administration of the most nutritious food, in the most easily assimilable forms, and in as great quantities as can be absorbed, together with tonics and stimulants *pro re nata*, is the line needful for the best results. In such cases the blood is scant or poor in quality, the blood-pressure low, and the pulse rapid; the heart is wearing itself out in the effort to meet the demand with an inadequate machinery. In such cases purgation must be mild, if at all admissible. In the sthenic type, on the contrary, general symptoms are brought out with such vehemence as to thwart their very purpose by their intensity. The blood-pressure is high, and the heart may become exhausted working against an undue backward pressure. Here the food must be light, of non-stimulating character, and given in small quantity. Elimination may be actively employed, especially by purging, and the blood-pressure may even be cautiously reduced by the administration of drugs. There is no place for stimulants in these cases unless exhaustion is apparent.

(*c*) *Increase of Specific Resistance.*—The greatest advance of recent times in the control of infections is the ability to raise the resistance of the individual against an infection with which he may be afflicted, or to absolutely fortify his body against any further evil from such infection. In the administration of antitoxins the latter end is reached, and, though the number of bacterial species against which such therapy is potent is small, nevertheless the results are astounding. The method of raising the specific resistance is best illustrated in the treatment of inflammation produced by the Klebs-Löffler bacillus. If the toxins have not already overwhelmed the nervous centers, it may be considered an unfailing cure. On the other hand, there are many species of bacteria against which the resistance may be gradually raised. In violently acute infections this method is, unfortunately, worthless, for the poisons are so abundant and their action is so swift that no dependence can be placed in the increase of protective bodies; the patient dies before they can be brought into action. But in the less violent acute cases, in recurrent acute infections, in the subacute and chronic cases, many infections are more satisfactorily combated thus than in any other way. The method is more satisfactory if the usual means of treatment are used conjointly. The resistance is raised by the administration of vaccines, the methods of administration and the actions of which have been explained in a previous chapter.

Operative Treatment.—When, by experience, it has been learned that an inflammatory process once established in an organ cannot be safely cured by the non-operative methods, and that the process persists as a chronic inflammation, or in spite of apparent recovery, relapses or recurrences are very likely to occur or in a special case have occurred; where complications and sequelæ follow with sufficient frequency to render non-operative methods dangerous, and when these methods fail entirely to give relief, operative treatment is indicated, either at once, without resort to the usual methods of treatment, or, if they are satisfactory for the acute attack, the operation may be done subsequently. Empirically, surgeons have learned in what conditions the operative is to supersede non-operative treatment. The most notable instance of frequent demand for operative treatment of inflammatory processes, either without resort to non-operative or after the benefits of the latter have been obtained, is appendicitis, for which the only rational treatment is appendectomy at as early a moment as possible; chronic inflammation of the uterine appendages, acute or chronic pancreatitis, or cholecystitis and acute osteomyelitis and epiphysitis. In application of operative conditions rare judgment is necessary to determine at what stage of the process it is necessary to operate. However, with the exception of the pelvic viscera, it may be given as a safe guide that the sooner after the diagnosis is made the surer the chance of cure by resort to open surgical procedure.

CHAPTER V

SUPPURATION

Suppuration is the formation of pus on or in the tissues, and is in practical work always the result of infection. Bacteria capable of producing pus are called pyogenic germs, and, while many bacteria may produce disease without the production of inflammation and pus, all the pyogenic germs are capable of producing inflammation. It may further be stated that pus can be formed in the tissues only as a result of the inflammatory process. Exceptions are produced experimentally by the hypodermic injection of croton oil or turpentine, but they have no bearing upon practical pathology and surgery. Injection of sterilized pus and of the filtrate from it produces suppuration; the toxic products of a few of the saprophytes may likewise cause pus-formation when deposited in the subcutaneous tissues.

Definition.—Pus is a creamy fluid of yellow or greenish-yellow color, of alkaline reaction, and having a specific gravity of 1030 to 1033.

The above description is that of the "good, laudable pus" of the fathers, who considered its appearance in a healing wound as a very favorable sign. But these terms are no longer applicable—pus is neither good nor laudable.

The reaction of pus is usually alkaline, but at times is neutral or faintly acid. Acid pus is found in old cerebral abscesses, but is not confined to these.

Pus is frequently malodorous, and this odor is due to the presence of some particular organism, as the colon bacillus, or to a mixed infection which causes decomposition. The odor is due to formation of hydrogen sulphid, butyric, lactic, and valerianic acids.

Varieties.—There are several varieties of pus: (*a*) Pus, or normal pus, the "good, laudable pus" described above. (*b*) Ichorous pus, which has an unusually small percentage of solids, and is acrid and irritating to the integument if allowed to remain long in contact with it. (*c*) Sanious pus, which contains enough red blood-cells or hemoglobin to give it a reddish or blood-stained appearance. A red pus has been described by Ferchmin, the color depending on pigment produced by an unnamed bacterium; the red is bright, like the color of blood, and later changes to violet. (*d*) Fetid pus is self-descriptive; the odor may be produced by the pyogenic bacteria or by infection with the bacteria of decomposition. Pus found in connection with the lower alimentary tract and in the perineal region is especially likely to be fetid. This is more often but not invariably so when a perforation has occurred during or preceding abscess formation. (*e*) Blue, green, or cerulean pus is due to infection with Bacillus pyocyaneus (*q. v.*). (*f*) Sterile pus is occasionally seen, but in practical work all of it is considered infected.

Liquor Puris.—On allowing pus to stand for a time in a jar it separates into an upper fluid layer and a nether layer of solids. About 85 to 90 per cent. of pus is fluid. The fluid portion of pus is called liquor puris, and is a watery, straw-colored, or clear fluid. It is derived from blood-plasma and from the fluids resultant upon the peptonization of tissues by bacteria. Liquor puris contains, in addition to the toxins of the bacteria constituting the infection, fats, globulin, albumoses, tyrosin, leucin, mucus, and cholesterin. The latter is found particularly in old pus. No fibrinogen is found, but in it are found bactericidal and digestive substances and ferments, whose origin is attributable to the tissue cells and to the bacteria. The salts of sodium, calcium, and magnesium are found, the former in the form of chlorids and the latter in the form of the two phosphates. Liquor puris could not be supposed to be entirely free from bacteria, owing to imperfect sedimentation.

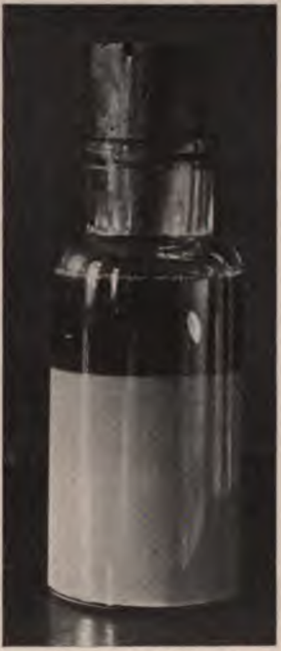

Fig. 18.—Bottle of pus separated into débris and liquor puris.

Débris.—The débris (or solids) of pus contains large numbers of leukocytes, chiefly polymorphonuclear, which may or may not contain bacteria, the granular material remaining after all (leukocytes chiefly) disintegration; the shreds and fragments of tissues, characteristic often of the site of pus formation, red blood-cells, which are accidental, and, most important of all, bacteria.

If the suppurative process occurred in a region abounding in fat, sufficient quantities of it may be present to float as globules on the surface of the discharged pus.

In gasogenic (pyogenic infections) gas is formed during the development of the infection, but escapes at the time of incision.

This is not the only instance, however, in which tympanitic abscesses appear; they may appear as the result of infection, but especially trauma plus infection in connection with or in proximity to the alimentary and respiratory tracts.

Pus is produced by the peptonizing action of bacteria on the tissues, and in by far the majority of cases the bacteria responsible for pus-formation are the staphylococci, which, as a rule, cause a localized suppuration, as seen in acute abscess. Streptococci are less likely to produce pus; they produce a spreading inflammation, usually rapid and extensive; however, streptococci do cause suppuration, especially if the inflammation continues for several days. The peptonizing action of streptococci is more marked when their culture is more or less deprived of oxygen. Although the above-mentioned bacteria are responsible for the vast majority of primary suppurative processes, and for suppuration following upon some primary non-pyogenic infection, there are a goodly number of bacteria occasionally producing suppuration, and a few which, though often producing disease, rarely cause suppuration in pure culture. After the staphylococci the most frequent pus-producer is the diplococcus of pneumonia, and, like the pyogenic cocci, it is not selective in its action upon the tissues, but may affect bone, soft tissues, and the serous cavities alike. Bacillus pyocyaneus is an occasional cause of suppuration, being characterized by the cerulean hue seen in its cultures. Bacillus coli communis is often found in mixed or pure culture in suppurative processes in or near the alimentary tract, and is found particularly in suppuration of the bile-tracts, as in cholangitis and hepatic abscess. Bacillus typhosus now and then produces a suppurative process, often some time subsequent to symptomatic recovery from typhoid fever. The bacillus may lie dormant for months or years, and then cause abscess or empyema, giving pure culture on investigation. The parts usually affected are bones, cartilage, and the biliary tract; other tissues are occasionally affected by it. The infections thus arising from Bacillus typhosus are difficult to manage, both from the standpoint of treatment and from the prophylactic standpoint, as all of them are typhoid carriers, and, unless the nature of the infection be suspected from the history, a wide distribution may occur before its source is determined. The bacillus of anthrax and some of the micrococci have also been shown to be occasionally pyogenic. In addition to the bacteria, which are habitually or rarely pyogenic, it is well to remember that certain fungi produce suppuration; of these the most important are actinomyces, blastomyces, Oïdium albicans, sporotrichia, and Trichophyton tonsurans. Secondary infections may occur in cultures of fungi the same as in those of bacteria.

The puruloid material found in cold abscesses is frequently called tubercular pus. It is distinct from the pus of acute infections, and is usually very characteristic, and easily recognizable once one is acquainted with it. It is formed by the breaking down of caseous material and the addition of leukocytes and fluids from the tissues. It is of a lighter color, usually almost white, is thinner than ordinary pus, and contains masses or lumps of undissolved caseous matter, a fact of great practical value, as the lumps are a frequent hindrance in efforts at aspiration of cold abscesses. The fact that tubercular pus, when coming into contact with serous or wound surfaces, does not cause acute inflammation and prevent healing *per primam* does not argue that such pus is sterile. On the contrary, most dangerous infection may result from such an accident. Cultures and inoculations always demonstrate the presence of Bacillus tuberculosis.

PUS ABSORPTION

The first fact to be gathered relative to pus absorption is the circumstances that favor that absorption. In many instances, if there is a large area of surface uncovered by epithelium, enough toxins may be absorbed to produce toxic symptoms; and yet cases are constantly appearing in which a mucous membrane is bathed with pus, or a large granulating area is pouring out large quantities of pus, with little or no constitutional symptomatology. On the other hand, a very small suppurative focus, from which there is no free vent for the pus, may produce the most violent symptoms. The virulence of the infection, *cæteris paribus,* is necessarily one of the factors determining the symptoms present. Second, the absorptive capacity of the surface or tissue with which the pus lies in contact. Third, the area of that surface; and, fourth, the tension under which absorption takes place. So, when pus is present in the peritoneal cavity it produces less dangerous symptoms if it comes in contact with the lower pelvic peritoneum rather than with the upper, since the diaphragmatic portion is more absorptive than the pelvic portion. Again, if a portion of the peritoneal cavity only be affected, the greatest care is demanded in surgical work not to scatter the infection over a wider field. A factor that militates against absorption of the poisons of pus is the formation of cicatricial tissue around the focus, but, unfortunately enough, this is found to occur extensively only after the lapse of some weeks, and cannot be of value in the most dangerous acute conditions. The more closely in touch with the nerve-centers a suppurative process lies the more dangerous it is, for manifest reasons. When a suppurative process affects the endothelium of the circulatory apparatus, or when, by proximity to the vessels, the pus may burrow its way through the vessel walls, the outlook is extremely grave, owing to a direct infection of the blood and consequent wide dissemination of septic emboli.

An individual who is ill from the absorption of poisons from pyogenic bacteria is said to be septic.

Symptoms of Pus Absorption.—The symptoms of pus absorption are as varied as are the degrees of toxicity and the dosage taken into the circulation in a given time. There may be a small quantity of poison absorbed and the virulence may be slight, so that the only symptoms noticeable are a slight rise of temperature and malaise. This may continue for a long time, and the cause of trouble remain obscure. The classic symptoms of pus absorption (manifestly in sufficient quantity to produce a marked reaction) are chills, fever, and sweats of an irregular type. There may be one chill; it is usually repeated at uncertain intervals unless the cause is removed. The chill may be very slight and of short duration or a mere chilliness, or it may be violent, and last from twenty to sixty minutes. The chill may be repeated several times in twenty-four hours, may come every day, or every other day, with a deceptive regularity that misleads the clinician into a diagnosis of malaria. There may be several chills and then an entire cessation of them. The fever is as irregular in its course as the chills; its typic feature is this irregularity; it may rise and fall several times a day, run high one day and low the next, high in the morning and low in the afternoon. On the other hand, it may at times be so regular as to cause confusion with malaria or typhoid. The fever of pus absorption is a continued fever usually. Remissions occur frequently; intermission less frequently, and then the temperature goes to subnormal. Therefore, by simply looking at a carefully kept chart one will often be able to say that only a septic patient could produce such a picture. Unfortunately, this is not always true.

Sweats are the last of the septic trio. They, too, are variable in degree. One case presents only a clammy skin, which is cold and has a peculiar unpleasant feel, like the skin of the dead. In another instance the sweats are drenching and often repeated. The chills, fever, and sweats may occur in any relation to each other; any one of them may be absent without affecting the diagnosis materially, but the fever does not remain absent long except in severely poisoned cases; and the sweating, when thought to be absent, can usually be discovered by close observation.

It is sufficient, to show the difficulty of diagnosis, to say that, owing to irregularities in the four conditions, typhoid, malaria, tuberculosis, and sepsis have to be differentiated with utmost care.

Besides the above symptoms, the presence of additional corroborative symptoms is usually observed. Malaise, headache, exhaustion, loss of appetite, coating of the tongue, constipation, high color, and diminished quantity of urine and the general appearance of the patient, whose facies is pinched and whose features are drawn and contracted, whose countenance is pale, and with perhaps cyanotic lips, and whose expression is anxious, are all seen in the typic picture of septic poisoning. Patients who are absorbing pus lose weight; in the severe cases with incredible rapidity, and those who have an unexplainable and persistent loss of appetite should, according to Musser, always be investigated thoroughly to find or to exclude a suppurative focus. The leukocyte count is of very great value in acute suppurative processes, but of little or no service in the chronic.

In certain cases of septic intoxication the symptoms assume the appearance of a well-developed typhoid condition.

The fact that pus absorption may cause only a slight symptomatology does not excuse failure to search for the cause, and, having determined that it is septic, the exact location must be diligently sought out. First, for the reason that immeasurable mischief may be done by neglect of mild pyogenic infection; and, second, because the conditions which must be differentiated from it may prove even more dangerous. They are malaria, typhoid, tuberculosis of various structures, and malignant disease, especially that affecting internal organs. Only by the most faithful search, by physical examination, and by laboratory methods can the diagnosis be assured.

Suppuration occurs on the surface of the body, in wounds and sinuses, on the mucous surface, in mucous and serous cavities (empyema), and in the tissues (abscess).

ABSCESS

Definition.—An abscess is an accumulation of pus circumscribed in a cavity of its own formation.

Etiology.—The cause of abscess is pyogenic infection, which may have been deposited by injury or accident, by the lymphatics, or by the blood-current. In certain instances the infection seems to have passed through the epithelial coverings without previous injury. The possibility of bacteria entering through intact surfaces has been demonstrated by rubbing the skin of the forearm with pure cultures of Staphylococcus aureus.

Furuncle, Boil.—Furuncle, or boil, is a cutaneous abscess due to a circumscribed inflammation of the corium and the subcutaneous connective tissue. They may be single or multiple, and when multiple they may be synchronous or successive. The appearance of several furuncles at approximately the same time or in successive crops is termed furunculosis.

Whitlow, Felon.—Whitlow, felon, bone-felon, panaris, ritium is an abscess formed deep in the phalanges. I situated either in the deep connective tissue or subperios terms being more appropriately defined as a subperioste geal abscess.

Onychia, Paronychia.—Onychia is an abscess of the ti the nail of the finger. Paronychia is an abscess in or matrix of the nail.

Carbuncle.—A carbuncle is an abscess which results siderable sloughing of the cutaneous and subcutaneo

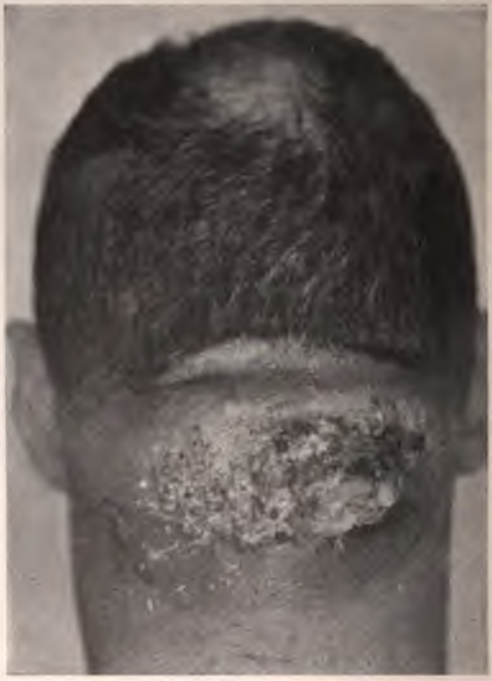

Fig. 19.—Carbuncle of nape of neck.

It is sometimes defined as a multilocular abscess in w are several foci of necrosis and suppuration, and in which unite by necrosis of the intervening tissue. Carbuncles most often on the neck, back, and buttocks.

Pathology of Acute Abscess.—The pathologic chang tissues that surround an abscess are very easy to underst one recalls that abscess is invariably the result of an infla In the central portion of the inflamed mass the tissue nec is peptonized and converted more or less completely

On the border between the abscess cavity and the inflamed tissue the process of repair undertakes to heal the lesion. So that one sees on the outside inflammation, next within this is a healing process, granulation or embryonic tissue, and in the center pus and necrotic tissue. The changes occurring in abscess have been graphically illustrated as follows: From without inward, (1) a zone of hyperemia; (2) a zone of congestion; (3) a zone of stasis—diapedesis and exudation are abundant in the latter two; (4) a zone of embryonic or granulation tissue; (5) the shreds and unseparated necrotic tissue lining the abscess cavity; (6) pus. In furuncles a core is present, representing the unpeptonized remains of the necrotic mass. This is attached to the surrounding connective tissue or separated from it, according to the advancement of the process. After complete separation of the dead tissue from the abscess wall the granulation tissue rapidly fills up the cavity with scar tissue, but it cannot advance far with the work until this pus has been given free exit.

The extent and behavior of an abscess depends largely on the anatomic limitations of its site of formation. In one instance an abscess forms, and can only extend by rupture of rigid walls of fasciæ or bone surrounding it, and the pus is on this account little likely to escape from its primary focus. In another instance the abscess formation may be in the midst of a homogeneous but easily destructible tissue, and the action of the infection may gradually destroy more and more of the tissue. Here the natural limitations do not assist the pathologic in preventing extension. In still another case the abscess forms in a region where escape is favored by the relative position of the planes of fasciæ or by openings for blood-vessels, nerves, and tendons, and any marked accumulation of pus is likely to find its way from the primary focus to a near or remote field. Gravity influences the direction of escape, other things being equal. The possibility of such an accident, and the anatomic fields where it is favored, must be borne in mind, for, while in its original site the abscess may be accessible and easily treated, its new lodging place may present insurmountable difficulties.

Types of Abscess.—Below are given a number of terms applied to abscesses. While all of them are either acute or chronic, their significance is of sufficient importance to be given in detail. Such terms as are self-defining or refer to anatomic location are omitted, unless they require some special comment.

Alveolar abscess, gum-boil, or parulis, is an abscess of the gum, associated with an infection in, around, or predisposed to by the teeth. The pus forms at the root of the tooth, usually at the apex, following a periostitis, and by absorption of the bone gains escape under the mucoperiosteum. The causative agency of th tooth and the sinus through the alveolus, allowing escape of th pus, should always be remembered in treatment.

Amebic abscess, or tropical abscess, is due to invasion of th liver, through the portal vein according to some, while others clai the route is through the bile-channels, by the ameba dysenteri and secondary to the lesions produced by this protozoön in th lower alimentary tract. The abscess may be single or multipl and is, of course, more amenable to treatment when single. It usually found in the right lobe of the liver, and may be recognize

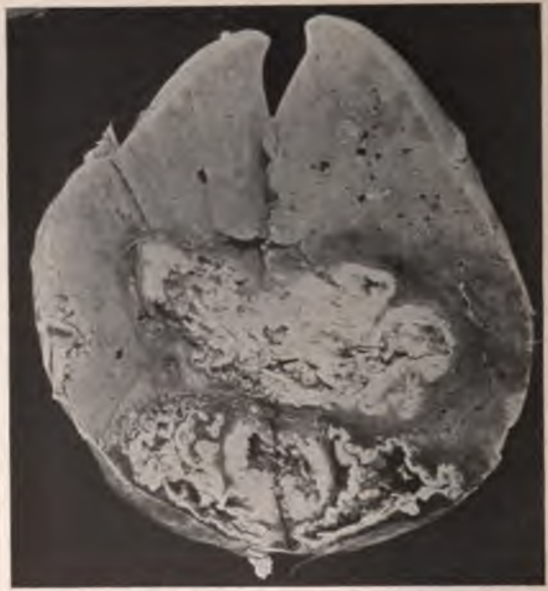

Fig. 20.—Multiple abscess of liver. (× about $\frac{1}{3}$.)

as hepatic abscess by the appearance of liver-cells in the this is of especial value when rupture into a bronchus has occur Amebic abscess, often of enormous proportions, may contain causative ameba, often associated with pyogenic bacteria, but times shows no causative organism, and has thus gained in th cases the manifestly incorrect name of idiopathic absce Strangely enough, tropical abscess occurs with greater frequen in the milder cases of amebic dysentery.

Atheromatous abscess, chiefly of pathologic interest, and belonging in the present group except by virtue of its name, i collection of cholesterin with other material under the intima arteries in chronic endarteritis. By rupture into the lumen of the vessels it causes atheromatous ulcer.

Bezold's abscess, or disease, is the condition resulting from perforation of suppurative mastoiditis into the tissues of the neck, and causing suppuration, which infiltrates the loose tissues of the neck and produces a brawny induration.

Brodie's abscess is usually tubercular. It occurs usually in the head of the tibia, occasionally in other bones.

Canalicular abscess is an abscess of the mammary gland which has ruptured into a lactiferous duct, and whose contents thus escape at the nipple and may cause serious illness of the infant if allowed to nurse the diseased breast.

Caseous abscess contains a cheesy matter, and is usually due to tubercular infection. It is a subdivision under chronic or cold abscess. The caseous material is mixed with the so-called tubercular pus, and represents that part of the tuberculous product which has not liquefied. In cold abscesses the presence of caseous material interferes with aspiration.

Cold, or *chronic, abscess* is of slow formation compared with acute abscess; it results from chronic or subacute inflammations, usually tubercular, and the name contra distinguishes it from acute or hot abscess. It shows little or no local rise of temperature in the surrounding structures.

Congestive abscess is one in which the pus cannot accumulate at the site of formation owing to resistance of surrounding structures, and is hence forced to escape and accumulate at some convenient point. It is sometimes classed as synonymous with wandering or hypostatic abscess. It is exceedingly necessary to know that such abscesses do not form *in situ*, as treatment fails then to reach the real source of disease.

Constitutional abscess forms as the result of general or constitutional infection and is insignificant in comparison with the favoring pathology. Pyemic abscesses belong to this class and tubercular abscesses do at times.

Dry abscess is one in which the fluid contents are absorbed and the residue is more or less completely removed, but no rupture has occurred and no incision has been made. It is an abscess that dries up.

Dubois' abscess is a supposed abscess of the thymus gland in syphilitic children, and was formerly claimed to be pathognomonic of that disease. It is neither pathognomonic nor is it abscess, but is due to postmortem softening or to cyst formation, the contents being puruloid. "They have nothing to do with syphilis" (Kaufmann).

Embolic abscess, secondary to embolism, forms in or around an embolus, and is due to infection carried in the embolus or predisposed to by the disturbance of nutrition caused by lodgment of the embolus.

Encysted abscess occurs in serous cavities, and occupies only a portion of the cavity, being confined by adhesion of serous surfaces by plastic exudate, which may organize. The abdominal and pleural cavities are affected.

Fecal, stercoraceous, or *stercoral abscess* occurs in connection with the colon, sigmoid, or rectum, and contains fecal matter.

Ischiorectal abscess forms in the ischiorectal fossa, and is of especial interest because it is the cause of fistula in ano consequent upon rupture or incision, and because, in the majority of cases, it is of tuberculous origin. Both of these facts demand consideration in the treatment and prognosis of ischiorectal abscess. When allowed to rupture there may be an external or an internal opening or both. At times both fossæ may be occupied by the abscess and result in a horseshoe fistula.

Lacunar abscess is one forming in the lacunæ of the urethra. They are usually of gonorrheal origin.

Marginal abscess occurs at or near the margin of the anus, either on the skin or mucous membrane. They originate from infection admitted through the solitary glands or Lieberkühn's follicles, hair-follicles, and sebaceous glands. They may be small, and have almost the appearance of acne, or, by infiltration, may affect a considerable superficial area. They do not extend deeply enough to affect the ischiorectal fossa.

Mastoid abscess, which should properly be called an empyema, is an accumulation of pus in the cells of the mastoid, and is secondary to infection of the middle ear. It is frequently associated with or followed by serious intracranial complications, as thrombosis of the lateral sinus, cerebral abscess, edema of the brain, and meningitis.

Metastatic, secondary or *pyemic, abscess* is always secondary to some more or less remote infection which gains access to the circulation, usually in the form of an infected embolus, which produces the secondary abscess at its point of lodgment. The most common conditions showing metastatic abscesses are pyemia, ulcerative endocarditis, and septic thrombosis. In the true sense of the term metastasis embraces also those secondary abscesses whose infection is transmitted through the lymph-channels, although it is usually accepted to be transmitted by the blood.

Miliary abscesses are secondary or metastatic, multiple, and of small size, like millet seed. They are not simply multiple, but usually numberless, so that large viscera, like the liver and the spleen, will show them throughout their volume. Their presence indicates a hopeless prognosis.

Milk abscess occurs in the female breast, and is especially frequent in nursing women.

Mural abscess is found in the abdominal wall, between peritoneum within and skin without. It is of especial interest, because of the necessity for determining whether it is an intra- or extraperitoneal abscess. Mural abscess may be secondary to laparotomy, especially when an infected structure, like a gangrenous or suppurative appendix, is excised. They are often observed under these conditions with no sign of coincident peritoneal infection.

Ossifluent abscess forms as a result of bone infection. The abscess may be contained within the bone and lie under the periosteum or escape through cloacæ in the bone, then through the periosteum, and be found in the soft tissues, often at sites deceptively remote from the primary lesion. The primary focus may be discovered by opening the abscess and following the sinus or by skiagraphs, either with or without previous injection of bismuth paste; but the skiagrams are more definite and reliable if the paste is used.

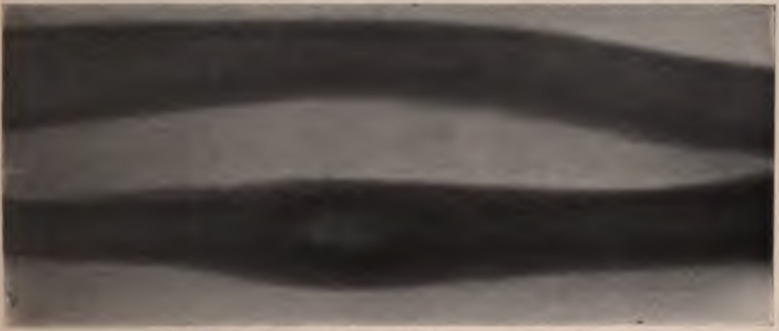

Fig. 21.—Abscess in medullary canal of ulna.

Perforating abscess is one that perforates its limiting wall. A hepatic abscess may perforate into the greater or lesser peritoneal cavity, or a pulmonary abscess into the pleural cavity.

Perinephric, or *perinephritic*, *abscess* forms in the tissues surrounding the kidney, especially in the poorly vitalized perirenal fat. The infection may be primary in the perirenal tissue or may, as some think, be due to infection brought to the kidneys in their effort at elimination of bacteria, and especially via the lymphatics from the surrounding tissues. In the latter instance it is secondary to an infection situated elsewhere in the body. Perinephric abscesses may attain enormous size, and are either unilateral or bilateral.

Peritonsillar abscess, or quinsy, is an abscess affecting the tonsil and the peritonsillar tissue. This abscess may cause marked destruction of tissue. It occurs in individuals of plethoric habit, and is rarely observed in the very young or very old. The infection gains entrance through the mucous membrane of the fauces or the tonsil, through the tonsillar crypts. By delay in treatment the abscess may burrow into the retropharyngeal space and produce a retropharyngeal abscess, or by extension into the thorax produce a suppurative mediastinitis or pleurisy; edema of the larynx is sometimes a complication. In cases of so-called cryptogenetic pyemia and other suppurative conditions of obscure origin the tonsils should be closely examined.

Postpharyngeal, or *retropharyngeal, abscess* is situated behind the posterior pharyngeal wall. It is usually a secondary or a wandering abscess, due to extension of infection from some neighboring inflammatory process, or rather to the escape of pus from some adjacent suppurative focus into the loose postpharyngeal connective tissue. The source of retropharyngeal abscess is usually the bones of the cranial base, the upper cervical vertebræ, infections about the tonsils and fauces, and of the deeper cervical lymph-nodes. They may be acute or chronic, and in either instance are of intense concern to the surgeon on account of their danger, whether treated or left alone. A large retropharyngeal abscess may interfere with swallowing or respiration, especially if it be acute and considerable edema be associated with it. There is the constant danger of escape downward along the loose planes of connective tissue into the mediastinum or of rupture into the pleural cavity. It may rupture into the pharynx and cause death by strangulation during exertion, as when an anesthetic is being administered, or during sleep; or, if strangulation be escaped, septic aspiration pneumonia may follow quickly. If these accidents are avoided, and if the abscess is opened or ruptures into the pharynx, the constant deglutition of the bacteria ejected may cause grave complications, far graver often than the primary condition, or a secondary infection may be admitted through the opening, and render a previously favorable condition hopeless.

Psoas, or *lumbar, abscess*, usually tubercular, is a wandering abscess whose pus forms in a tuberculous focus in the lumbar or lower thoracic vertebræ and escapes into the sheath of the psoas muscle, under which it gravitates downward, until it meets with sufficient resistance near the level of the pubic spine or Poupart's ligament to check it. The bulging of the abscess may lie above Poupart's ligament, when it may be confused with intraperitoneal conditions, or below the ligament, and be confused with femoral hernia. The abscess usually points in Scarpa's triangle external to the femoral vessels. Occasionally the pus burrows along the course of the circumflex vessels and appears behind the trochanter major, or it may rupture into the bursa lying between the psoas and the capsule of the hip-joint, and thus pour its contents into the joint cavity. In addition to the above, the pus may burrow through the psoas sheath into the iliac fossa, into the pelvis, beneath the pelvic fascia, through the great sacrosciatic foramen, and appear in the gluteal region, or through the obturator fascia into the ischiorectal space, and appear as an ischiorectal abscess. Rarely, the pus from psoas abscess escapes into the thigh below the hip and may reach as low as the knee.

Residual abscess, or *Paget's abscess*, is one which forms at the site of an old infection or abscess, whose incompletely destroyed residue remains indefinitely encysted in the tissues, and produces no disturbance until the bacteria are called into activity by some accident, such as an injury, or until some infection may be lodged at this focus and give a new impetus to the dormant infection. The bacteria usually found in these cases are tubercle bacilli, and so a serious complication may grow out of an insignificant trauma. The possibility of such an accident must be borne in mind in all cases where surgical interference is recommended subsequent to the apparent healing of a tubercular lesion.

Shirt-stud abscess has two cavities, a superficial and a deeper one, connected with each other by a communicating sinus.

Stitch, or *stitch-hole, abscess* forms around or in contact with sutures; usually sutures which have been introduced through the skin. The sutures carry the infection from the surface and outer layers of the skin; hence, some surgeons recommend the introduction of all sutures toward the epithelial surface, never from it; or the infection may be brought into the skin and subcutaneous fascia by capillarity of the suture. Stitch abscesses occur with too great frequency, usually in cases where no deeper infection is manifest. The infection of stitch abscess is most frequently Staphylococcus epidermidis albus, which causes, as a rule, a mild infection with little tendency to spread. Of course other infections are found, usually caused by bacteria which habitually attach to the body surface or live in the glands and follicles. The infection may also be attributed to soiling the tissues during the removal of pathologic tissue through the wound. Stitch abscess is less likely to form, and, in case it should form, likely to be of smaller size, if the sutures are not allowed to make undue pressure on the tissue within their grasp. Removal of the suture concerned and gentle cleansing is usually sufficient to relieve them.

Subdiaphragmatic, or *subphrenic, abscess* is usually secondary to an infection situated in the upper abdomen and to appendicitis.

It is frequently tympanitic, and occasionally relieves itself by burrowing through the diaphragm, across parietal and visceral pleura adherent to each other at the base of the lung, and into the lung tissue, whence it escapes through a bronchus. If the pleuræ are not adherent the perforation of the diaphragm results in pyothorax or pyopneumothorax.

Thecal abscess is an accumulation of pus in a tendon sheath.

Tympanitic abscess is one which contains both pus and gas. This gas may be produced by the causative infection, or it may be due to the entrance of gas into the tissues through a wound which produces a communication, for example, with the lung or a bronchial tube.

Urinous abscess contains pus and urine which has extravasated into the tissues through lesions which communicate with the urinary apparatus. They are seen usually in males, and follow strictures of the urethra in the majority of cases.

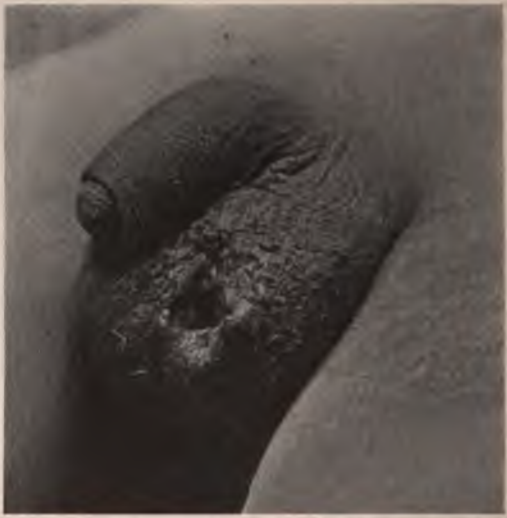

Fig. 22.—Ruptured uriniferous abscess resulting from strictured urethra.

Local Signs and Symptoms.—The local signs and symptoms o acute abscess are: (*a*) a history of an acute inflammation; (*b*) fluctuation; (*c*) softening; (*d*) pointing; (*e*) edema of surrounding sof tissues; (*f*) pus on aspiration.

(*a*) The history of inflammation embraces all the local and constitutional signs and symptoms; often such a history cannot b elicited. The duration of the inflammatory process prior to suppuration may vary from a few hours, as in fulminating cases, t several days.

(*b*) Fluctuation does not signify the presence of pus, but simply the presence of fluid, the nature of which must be determined by other evidence. By fluctuation one means the wave sent from one side of a cavity filled with fluid to the other. To determine its presence one hand is placed on one side, and the opposite side is tapped lightly and quickly by the other hand. The wave is produced by the latter and felt by the former. If the part be loose and soft, as in fat abdomens, more satisfactory examination can be done by having an assistant place the inner side of his hand against the surface between the palpating and the percussing hand, with the plane of the assistant's hand at a right angle to the line of transmission. The assistant must make firm pressure, but not enough to collapse the underlying activity. The assistant's hand thus interrupts the deceptive wave transmitted by the overlying soft tissues. In attempting to elicit fluctuation in the arm or thigh, especially in case of stout individuals or those whose muscles are well developed, it is necessary to place the palpating hand above or below the percussing hand, in the long axis, as an apparent fluctuation can be obtained normally by transverse palpation.

In many cases it is necessary to determine whether fluctuation is present or not, and yet impossible to place both hands in the position above recommended. This is manifestly true in rectal, vaginal, and oral examinations. By a little practice one may become able to recognize fluctuation or, if not that, the presence of fluid by using a single hand or a single finger. It is difficult to describe just what happens, but we may say that there is a tenseness and an elasticity which reminds one of the feeling of a rubber bag filled with water; or the surface may be struck with the finger which holds in touch with the mass, and catches the wave on its return from the opposite side.

Pseudofluctuation is fluctuation obtained in bodies not filled with fluid, or, better, not containing a cavity filled with fluid. Reference has already been made to the confusion arising from pseudofluctuation of the abdominal walls and of the extremities of stout individuals. It is found in certain tumors, especially lipomata when of fair size, and in the very soft or very vascular malignant tumors. It is also seen in cases of extensive edema, and may appear as an unquestionable fluctuation here. It may be impossible, under certain circumstances, to say whether fluctuation or pseudofluctuation is present.

(*c*) *Softening.*—There is a certain amount of induration in the ordinary inflamed structure. When a portion of this indurated infiltrated tissue is converted into pus, softening is observed, and if the pus cavity is palpable the softening will be found coextensive with the pus formation. The softening is all the more apparent when contrasted with the indurated, inflamed boundaries, but is less easily recognized when this boundary is wanting, as in subacute and chronic abscesses. The softness of an abscess large enough to palpate satisfactorily is greater than that of the softest normal tissues.

(*d*) *Pointing.*—The tendency of an abscess is to relieve itself by opening upon some surface of the body; the direction taken is along the lines of least resistance. As the peptonizing action of the bacteria continues, from a beginning central zone toward the periphery, the pus gradually approaches some surface, cutaneous, mucous, or serous, and when this surface is approached the resistance of the tissues to the pressure of the pus is reduced and the surface bulges at this point. This bulging is known as pointing. The place of pointing is that at which rupture of the abscess will occur if allowed to pursue its own course, although it is by no means always at the most advantageous place for emptying and thus healing the abscess. The place of pointing is that of greatest softening, that at which pus can be most easily reached by the knife or the aspirating needle.

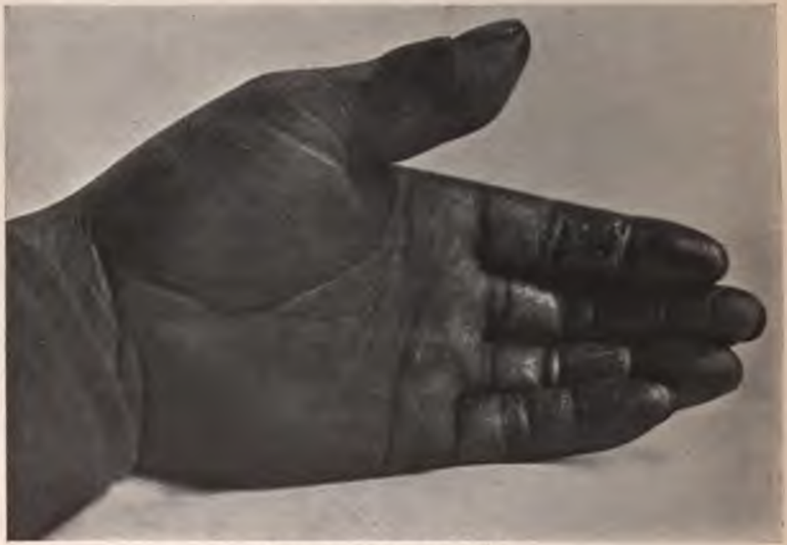

Fig. 23.—Infected hand.

(*e*) *Edema.*—Edema may be seen in many non-suppurative inflammations, especially in regions where the connective tissue is loose, as in the face and the external genitals. But in case of acute abscess edema is the rule, and is frequently of paramount importance as a diagnostic sign when other symptoms and signs are vague or wanting. The edema may be coextensive with the inflamed area, but not infrequently extends widely into surrounding healthy tissue. So in deep suppurative processes its presence is of especial value; still its absence cannot be accepted to signify that an abscess is not present. In suppuration of the mastoid, so-called mastoid abscess, edema may appear over the mastoid region, in abscess of the liver over the lower part of the right thorax, and in inflammation of the bones or joints, if suppuration is present, more or less edema will show.

(*f*) *Pus on Aspiration.*—The absolute proof of abscess is established when an aspirating needle can be introduced and pus drawn from the cavity. It is not a necessary procedure in most instances, and in many, where it is apparently necessary, it is positively contra-indicated. The contra-indication is found in abscess of a viscus, as a lung or the liver, where, in order to aspirate, the needle must be passed through a serous cavity to reach the diseased organ. When this is done and the needle withdrawn, its infected surface cannot fail to soil the peritoneum or the pleura, and at the same time leave a communicating tract between the serous and abscess cavity, which, however minute, favors to some extent the escape of pus. If it is considered necessary to do aspiration under such circumstances, it is permissible only with the understanding that if pus is found an operation will be undertaken before withdrawal of the needle. Now and then failure to find pus on aspiration is due to the passage of the needle completely through the abscess cavity. *Hence, it is better to maintain suction during withdrawal of the needle, so that the possibility of such an error may be eliminated.*

The constitutional symptoms of abscess are those of pus absorption, already discussed at some length. They may be so mild as to escape observation, or intense, even out of all proportion to the local condition. When the abscess is drained thoroughly the constitutional symptoms subside rapidly, and return only when reaccumulation of the pus is permitted, when a new abscess develops, or when some septic complication arises.

Diagnosis of Abscess.—There is no difficulty of diagnosis in case of superficial abscess, as a rule. If the skin is not involved, however, in the inflammatory process, or if the abscess is situated deeply among the muscles of the hip, in bone, in the cranial cavity, or in the thoracic or abdominal cavity, the greatest and most insuperable obstacles may thrust themselves in the way. Under such circumstances no single sign may be of diagnostic value, and many of the signs and symptoms may be absent or indifferent, or not demonstrable for want of apparatus and skilled assistance. So one must create for one's self as much as possible a picture of sepsis, of the patient who is absorbing the toxins of pus, and apply it in every instance, constantly cognizant of the fact that great and delusive variations are to be expected. Not only so; on the other hand, all other adequate explanations of the symptomatology must be excluded.

There are several lesions and combinations of lesions which must be excluded in making a differential diagnosis of acute abscess. Among these one of the most treacherous is the presence of a tumor or a cyst, of itself incapable of producing a rise of temperature, and whose existence is unknown to its host, complicated with the development of a febrile condition, capable of being considered septic. A still worse combination is found when such a tumor, especially if a cyst or a very soft solid tumor, becomes infected and develops all the local and constitutional signs appertaining thereto. The history would suffice if it could be obtained, but could not be of value further than to show that the mass antedated the symptoms; it could not exclude the possibility of an associate suppuration. In tumors, gummata, and cysts the definite outlines usually found are very unlike the more or less vague outlines of abscess. In those cases where carcinoma or sarcoma appears and produces febrile symptoms of low degree, the long continuance of the same case and the slow development of symptoms argues against acute abscess, but the accidents which befall in the course of these tumors may obscure the picture completely. One cannot forget that malignant tumors may develop rarely almost with the incredible rapidity of acute abscess. The differentiation of these conditions is found most difficult in the chest and upper abdomen.

Exclusion of aneurysm may present difficulties in inaccessible regions, where the centrifugal expansion of the aneurysm cannot with certainty be distinguished from the lifting of an abscess lying over a large vessel. When a mass of any kind lies over the course of an important blood-vessel, the most positive evidence of its nature must be produced prior to attacking it.

When a secondary or residual abscess develops in a mass of tissues bound together by adhesions its presence will often be discovered by awaiting the development of positive signs.

Abscess must be distinguished from inflamed cysts in or near the skin, as well as from those situated within the cavities of the body, for the very simple reason that the cyst will recur frequently when treated as abscess. The existence of the mass prior to the inflammation, the usually definite outlines, the location, the presence of a comedo if the cyst is sebaceous, the appearance of the contents when aspiration or excision is made, showing admixture of the cystic contents, and after incision the presence of a smooth limiting wall, argue for cyst and against abscess.

Complications and Sequelæ of Abscess.—Naturally the same complications and sequelæ may be found with abscess as with inflammation. They are infection of lymph-nodes of the nearest proximal group, lymphangitis, ankyloses, constrictions, and obstructions which follow them, or the immobilization of important organs, as lungs and heart. Thrombosis may occur, and does occur with great frequency when the abscess is in close proximity to a vein, illustrated best by thrombosis of the lateral sinus in abscess of the mastoid. Following thrombosis, embolism may come, resulting fatally without a second's warning, or, if the embolus lodges at a less vital point, infarction, secondary abscess, septicemia or pyemia with metastasis may develop.

Prognosis of Abscess.—The prognosis of abscess depends on the same factors as that of inflammation as far as they go, namely, the virulence of the causative bacteria, extent, accessibility, and the importance of the structure affected. Furthermore, it depends upon the degree of development or the amount of tissue destroyed; this not infrequently causes death after the abscess is cured and all infection removed; upon what cavities and organs are affected by its burrowing or rupture, and upon the pranks played by emboli and adhesions. The accessibility of abscess to treatment is of especial importance, for in many regions the accomplishment of safe and easy drainage offers insurmountable difficulties.

Treatment of Abscess.—The treatment of abscess may be divided into abortive treatment, operative treatment, and constitutional treatment.

Abortive Treatment.—When superficial inflammatory processes are seen early enough—*i. e.*, before pus has formed, or after it has formed in a very restricted area—abortive treatment may be employed with a fair degree of success. There are two antiseptics employed for this purpose: one is pure carbolic acid, a minim or two of which is injected into the center of the abscess with a small hypodermic needle. The objection to carbolic acid is that occasionally it surprises one by producing gangrene, and that if much of it should be used and be absorbed it will cause a serious nephritis. The other safer solution is glycerin containing 2 per cent. of formalin; of this mixture 5 to 10 drops or more, if the case demands it, may be injected. The abscess rapidly changes its appearance and the symptoms subside, the necrotic material being gradually absorbed.

Operative Treatment.—The treatment of abscess as such may be summed up in a very brief sentence—open, clean out, and drain.

If left to itself to rupture, the opening will be inadequate in most instances, is very likely to be situated at a point disadvantageous for drainage, especially if the abscess is deep or large, and entails greater suffering on the patient by delay and greater danger

of complications. Hence, when acute abscess is diagnos
treatment should be done at the earliest possible momen
size of the opening should be determined by the amount
the possible duration of drainage, and the location of the
The tegumentary coverings heal more rapidly than the
cavity, so provision must be made against too early closur
incision by making it large enough in the beginning. If a dr
tube is to be used, the opening will not need to be so large
drainage of a less rigid material is employed. The tendenc
average physician is to make the opening too small. The d
of the incision is determined first by the course of im
underlying anatomic structures, and should run parallel t
a transverse incision endangers them much more. If no
ant structures are in close relation to the abscess, the incision
be made, especially on exposed parts, in such direction as

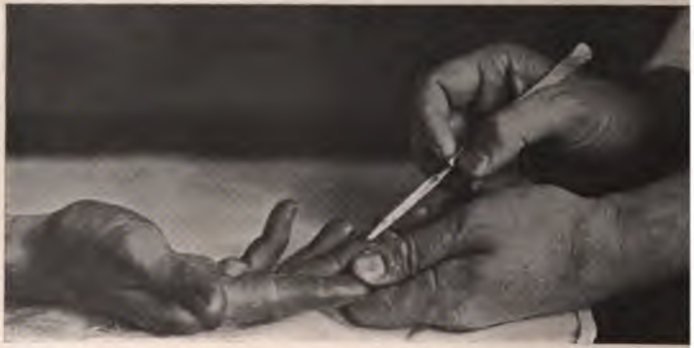

Fig. 24.—Incorrect method of incising finger.

the least disfigurement, namely, in the direction of the cr
the skin. The opening should extend well down into the
cavity, and not simply puncture it at the bottom of the i

Hilton's Method.—If the abscess cavity lies beneath a da
region, where an incision could not be safely made into it, it
to employ Hilton's method. Make an incision down to t
fascia or to the danger zone; pass a probe-pointed grooved
through the tissues into the cavity; its entrance can be rec
by the escape of pus along the groove, which is held upw
the lack of resistance to the advancing instrument, and
ability to make lateral movements without meeting with o
tion, much as one would know that a sound had passed fr
urethra into the bladder. Pass a pair of closed pointed
along the groove of the director into the abscess cavity, ope
and withdraw while held open. This tears an opening, b

not injure the vessels and nerves, which roll or slide out of the way of the forceps, but could not escape a sharp knife.

The place of pointing cannot be accepted as the most favorable point for opening an abscess. The incision should be so situated that drainage will be most perfect in the position to be occupied subsequently. Hence, if an incision is made, and on examination of the abscess cavity it is found that drainage will not be good, a second incision, or counteropening, will be made at the most advantageous point.

Cleaning the Abscess Cavity.—After opening an abscess the pus may be removed by irrigation with normal salt solution or by mopping with sponges; hydrogen peroxid may be used, but only when the opening is patent. If the size of the opening is large enough and correctly situated, and the drainage adequate, it matters little whether all the pus is cleaned out of the abscess cavity, for, the pressure off, the current of lymph in adjacent vessels is renewed and the drainage will take care of the discharge. In no case should one yield to the temptation to squeeze out the contents of an abscess, for by so doing the limiting walls of leukocytes may be broken up and a direct extension of the infection occur, or a thrombus may be dislodged from the mouth of a vein and allow the escape of pus directly into the circulation. Moreover, squeezing will bruise the tissue and favor necrosis. The application of a sucking cup, whose diameter is greater than that of the abscess, is the most satisfactory plan of evacuating pus. Removal of the core from furuncles should be done by lifting it out with a pair of forceps; if firmly attached, heavy traction should not be made on it, for the same reasons urged against squeezing. In a day or two it will be entirely separated and may be easily lifted out. If a few points are held by fibrous tissue they should be cut rather than torn.

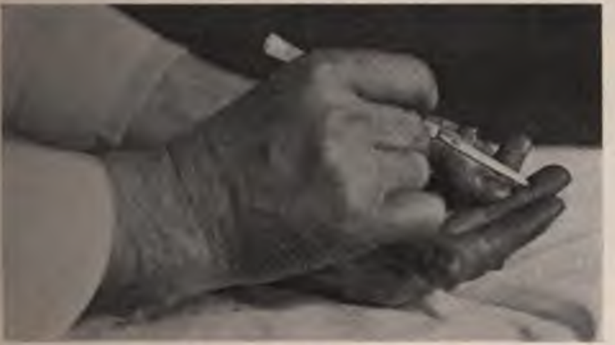

Fig. 25.—Correct method of incising finger.

Curetting the cavity of an acute abscess is an unnecessary and may be a very harmful procedure. So, too, the use of escharotics has little or nothing to recommend it, as the necrotic material will be disposed of in a very short time by natural processes. If a blood-clot is found in the cavity it should be removed; allowing time for it to be digested by the bacteria will cause unnecessary delay.

As soon as reaccumulated pus has filled the cavity, or as soon as the dressings have become soiled, a new dressing should be applied and the cleansing process repeated. Cupping at the time of dressings gives the double advantage of withdrawing the discharge and of hyperemia. The dressings should be changed once a day in ordinary abscesses and oftener in large ones.

Drainage.—This item in the treatment of abscess is frequently advised by use of the term "pack," which is applied too literally. The packing should not be tight; its object is to accomplish drainage, and it should be placed in the cavity loosely, and so distributed as to wick the fluids from the depths of the abscess most thoroughly. There is only one circumstance demanding that tight packing be done, namely, for control of hemorrhage; here it must be done tightly enough to stop the bleeding, and must not be removed until conditions demand it; even then it is to be removed with extreme caution, lest the hemorrhage be re-established. Drainage material has the additional object of maintaining an adequate opening until the abscess cavity can be obliterated by the healing process.

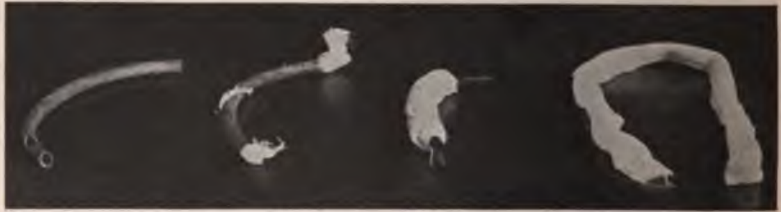

Fig. 26.—Drainage material ready for use.

The material used for drainage is manifold, depending on the size and location of the abscess. In small abscesses, where it is necessary to drain only for a few days, gauze is sufficient. Medicated gauze, especially if the medicament is bulky or if it contains an oily menstruum, does not drain so well as plain sterile gauze; also, after gauze becomes thoroughly saturated with pus and the meshes are blocked by the débris, it loses its capillarity and is inefficient. Hence, gauze drains should not be allowed to remain longer than twenty-four to thirty-six hours without changing. When packing is used to wall off spaces in serous cavities the purpose is an entirely different one and the gauze may be left longer *in situ*. Gauze drains, as well as others, serve their purpose better when covered with a moist dressing. It is more satisfactory to employ specially made gauze with two selvage edges for drainage. It is easier to introduce, leaves no frazzles behind when removed, and does not tear so easily during removal. When large cavities are packed with gauze an accurate account of the number of pieces must be kept, or the end of each successive piece should be fastened (usually by tying) to the end of the preceding piece; or, if introduced separately, the end of each piece should be held outside the wound, and all secured together at the end of the dressing.

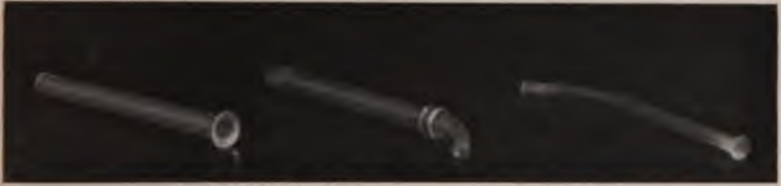

Fig. 27.—Glass drainage-tubes.

Drainage of slight quantities may be done by the introduction of a few strands of thread.

Drainage by tubes is the second widely employed method. Drainage-tubes are usually made of soft rubber, hard rubber, or glass, occasionally of metal. The soft-rubber tubes are usually preferred, except where there is danger of collapsing the tube by external pressure, as in deep drainage of the pelvis through the abdominal opening. These may be used as a single tube, or split longitudinally or spirally with a strip of gauze placed within the lumen and allowed to project an inch at either end, or the deep end of the tube may be perforated at short intervals, so that, if the end of the tube should be blocked, drainage may be continued. Rigid tubes may be perforated in the same manner.

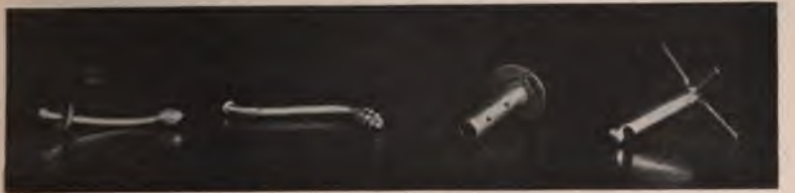

Fig. 28.—Metal drainage-tubes.

If drainage is insufficient, aspiration may be done by introducing a long syringe nozzle or a rubber tube and aspirating the contents as rapidly as they accumulate. This is especially necessary in drainage of the peritoneal cavity.

The maintenance of tubes in position is a very important, often a very troublesome, feature of drainage. This obstacle may be overcome by suturing the tube to the skin and fascia at the edge of the wound. The suture should not be drawn closely, as it is likely to cut out. Mixter's tubes and T-tubes are used to prevent their escape from the cavity, and, where a suture is placed in addition, they can escape in neither direction. The rubber spool is another very satisfactory device to prevent displacement of the drainage apparatus.

Treatment of Carbuncle.—In carbuncles the accepted treatment is a crucial incision into the mass, cleansing, and drainage by gauze packing. The necrotic mass and all tissue evidently about to necrose should be removed with the scissors, knife, or very sharp curet, otherwise drainage is very likely to be imperfect, and extension of the carbuncle into surrounding tissue will continue uninterrupted. The danger of carbuncle to life is much greater than that of simple abscess, and accordingly the incision must be free and the removal of tissue extensive. Another method of treatment, offering a surer prognosis and no longer average time for recovery, is excision of the entire inflamed mass, and subsequent treatment of the open wound, followed by skin-grafting if necessary.

The *treatment of a whitlow* should be inaugurated at the earliest possible moment after recognition of its true nature. A long deep incision should be made and packed with gauze. It is often necessary to employ in these cases the additional treatment laid down under Inflammation, especially moist heat.

In cases of multiple abscess, in furunculosis, in those who seem to have a general weakness against a particular pus-producing organism (the most common cause in these cases is Staphylococcus pyogenes aureus), and in every case of carbuncle that does not show the most prompt response to treatment it is imperative that immediate efforts should be made to raise the individual's resistive powers by nourishment, rest, and tonics, but especially by the administration of the vaccines indicated. These can be purchased in all the cities at prices within the reach of all. Opsonic indices, cultures, and specially prepared vaccines are unnecessary in most instances, and the selection of the proper vaccine, streptococcus, staphylococcus, or polyvalent can usually be done satisfactorily by clinical observation alone.

CHAPTER VI

SEPSIS

THE term "sepsis" is used to signify the general or constitutional condition produced by the action of pyogenic and of saprogenic bacteria. There are three fairly distinct types of sepsis, which are septic intoxication (sapremia), septic infection (septicemia), and pyemia.

SEPTIC INTOXICATION (SAPREMIA)

Septic intoxication and sapremia represent the first group, and are the simplest type of the septic condition considered from the standpoint of pathology, prognosis, or treatment. They are usually given as synonyms, but usage has gradually separated them into fairly distinct terms; still they are sufficiently similar to be treated under the same heading when each is throughly defined.

Septic intoxication is the constitutional impression made by the absorption of the poisons produced by pyogenic bacteria in the tissues. The pathology serving as the primary cause of septic intoxication, then, is a localized inflammatory or suppurative process. From this the poisons are absorbed, carried into the general circulation, and produce the varying pictures of intoxication. The bacteria do not gain entrance into the blood in great numbers and are not recoverable from it; there is not a wide distribution of the infection beyond the local extension. So septic intoxication may be accepted as a term used to represent the constitutional symptoms of a local suppurative or inflammatory process. The general symptoms developed in the course of an acute abscess are symptoms of septic intoxication; so are the constitutional symptoms of erysipelas, of appendicitis, of pelvic inflammations, etc.

Sapremia is similarly produced by the absorption of bacterial poisons from a localized infection. The nature of the infection is different. In septic intoxication the bacteria are pyogenic, in sapremia they are saprophytic, or, at most, a mixed infection of saprophytes and pyogenic bacteria. Therefore, in sapremia decomposition of tissue or of tissue products is going on in the primary focus, while in septic intoxication inflammation or suppuration is the local pathology. If both types of infection are present, sapremia is the term commonly applied. Hence, sapremia is usually seen associated with decomposition of blood-clots and

secundines subsequent to unclean abortions and deliveries, to th
accumulation of blood and necrosis in operative and traumati
wounds, and to gangrene.

Pathology.—The local changes are sufficiently indicated b
the above descriptions of septic intoxication and sapremia. I
these conditions the inflammatory, suppurative, or decompositio
process is capable of causing intoxication in direct proportion t
the virulence of the infection, the extensiveness of the lesion, an
the rate of absorption. Often, therefore, a very limited lesion ma
produce violent symptoms, whereas an extensive process situate
elsewhere will result in insignificant ones. The measure of th
danger, therefore, in either instance is the constitutional im
pression produced, except in those instances where the nature o
the infection or the vital importance of the structure affected ren
ders the outlook unfavorable regardless of the general symptom

The chief bacteria found in sapremic foci are the proteus grou
Bacillus pyocyaneus, and Micrococcus tetragenes.

The general pathology of sapremia and septic intoxicati
may be given in a single paragraph if one recalls that in saprem
the infection is chiefly represented by the bacteria of decomp
sition, probably rarely without an admixture of pyogenic micr
organisms, and that in septic intoxication the infection is of a pure
pyogenic nature. The most striking detail of the general path
ogy in these cases is the alteration of the blood-picture, whi
may be accepted as a fair index of the constitutional impressi
made. The leukocyte count is likely to be increased except
case of absorption of overwhelming quantities of poison. On t
other hand, the hemoglobin is reduced and the number of red ce
is diminished, caused by the hemolytic action of the poiso
which explains the cachectic appearance of septic individua
If the process becomes chronic, amyloid changes occur in the liv
spleen, kidneys, intestines, and blood-vessels. The clinical e
dence of extensive amyloid changes is shown by enlarged liver a
spleen, albumin and waxy casts in the urine, and low blood-pr
sure. Petechiæ are at times found in these types of sepsis, as w
as submucous and subserous hemorrhages, although they are l
frequent in sapremia and septic intoxication than in septicem
and pyemia.

Symptoms.—The symptoms of septic intoxication are tho
detailed under Inflammation and Pus absorption. The sympto
of sapremia are closely allied, and are as follows: As a rule, t
initial symptoms manifest themselves within twenty-four to fort
eight hours subsequent to infection of devitalized tissue, clots,
serum which have accumulated in some cavity of the body. The
may be an initial chill, but its absence has no diagnostic signi

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SEPSIS

THE term "sepsis" is used to signify the general or constitutional condition produced by the action of pyogenic and of saprogenic bacteria. There are three fairly distinct types of sepsis, which are septic intoxication (sapremia), septic infection (septicemia), and pyemia.

SEPTIC INTOXICATION (SAPREMIA)

Septic intoxication and sapremia represent the first group, and are the simplest type of the septic condition considered from the standpoint of pathology, prognosis, or treatment. They are usually given as synonyms, but usage has gradually separated them into fairly distinct terms; still they are sufficiently similar to be treated under the same heading when each is throughly defined.

Septic intoxication is the constitutional impression made by the absorption of the poisons produced by pyogenic bacteria in the tissues. The pathology serving as the primary cause of septic intoxication, then, is a localized inflammatory or suppurative process. From this the poisons are absorbed, carried into the general circulation, and produce the varying pictures of intoxication. The bacteria do not gain entrance into the blood in great numbers and are not recoverable from it; there is not a wide distribution of the infection beyond the local extension. So septic intoxication may be accepted as a term used to represent the constitutional symptoms of a local suppurative or inflammatory process. The general symptoms developed in the course of an acute abscess are symptoms of septic intoxication; so are the constitutional symptoms of erysipelas, of appendicitis, of pelvic inflammations, etc.

Sapremia is similarly produced by the absorption of bacterial poisons from a localized infection. The nature of the infection is different. In septic intoxication the bacteria are pyogenic, in sapremia they are saprophytic, or, at most, a mixed infection of saprophytes and pyogenic bacteria. Therefore, in sapremia decomposition of tissue or of tissue products is going on in the primary focus, while in septic intoxication inflammation or suppuration is the local pathology. If both types of infection are present, sapremia is the term commonly applied. Hence, sapremia is usually seen associated with decomposition of blood-clots and be resorted to; and here the use of antiseptic solutions may be especially valuable, as the bacteria are not, as a rule, buried in the tissues except in gangrenous conditions. Whether the general condition of the patient demands it or not, it is frequently necessary to use deodorizing irrigation for the comfort of both patient and attendants; the same end is likewise accomplished by packing the cavity loosely with gauze saturated with 50 per cent. alcohol, which is perhaps the most satisfactory plan, permanganate of potash solutions, 1 : 5000, or kresol or lysol in 1 per cent. solutions. These solutions are very satisfactory also for irrigation, as they combine antiseptic with deodorizing properties.

General Treatment.—General treatment is directed along two lines, namely, to hasten elimination of the poisons and to stimulate the vital functions until this is accomplished. Even in apparently violent cases the transformation in the course of a few hours wrought by local treatment is marvelous, inasmuch as the elimination of the bacterial poisons is very rapid. But if it is necessary to assist nature in such elimination, the utmost precaution is needed. Purgation of an exhausted patient, such as one sees in sapremia, can prove quickly fatal. If the bowels must be moved, let it be by high enemata. The only safe route of elimination should be by the kidneys, and the remedy is water. Normal salt solution must be administered in great abundance by mouth, by hypodermoclysis, by intravenous injection, by large retained enemata frequently repeated, or drip enemata. This method of elimination does not increase the exhaustion, whereas sweating and purgation do. In the more serious cases, in which extensive disintegration of the red corpuscles have taken place, direct transfusion of blood should be resorted to without delay. It is better to perform this operation at the same sitting, if possible, with that for removal of the infected focus.

Stimulation is usually needed and is produced by the administration of strychnin, whisky, and adrenalin chlorid. In the use of the latter drug its brief period of efficiency is to be remembered, and the doses should be repeated every two or three hours.

Nutritious, easily assimilated diet must be administered in as great quantity as the digestive organs can dispose of comfortably.

The crisis lasts a few hours and demands the greatest vigilance. If the temperature fails to come to normal soon after cleaning away the putrid material it may be accepted as signifying that the work was incomplete, that a septicemia has already been inaugurated, or that some complication is present. A rise of the temperature after it has become and remains normal a few hours indicates the need of dressing and irrigation. After the crisis is past a tonic and dietetic régime will be followed until the normal status is reached.

SEPTICEMIA OR SEPTIC INFECTION

The second subdivision of septic conditions, septicemia, is, while often difficult to distinguish clinically from the preceding, pathologically widely separated from it. In the preceding condition the local process is the important lesion; in the latter, whether the local changes be important or so insignificant as to be undiscoverable, they are nothing as compared with the essential feature.

Septicemia is the presence of bacteria, usually pyogenic, in the blood in sufficient quantity to constitute a diseased condition of that fluid. In almost any local infection it is doubtful if the blood ever escapes the presence of a few bacteria, but they are not present in such quantities as to be recoverable and are soon eliminated by the kidneys or liver. So, too, in many constitutional diseases, such as the infectious fevers, the blood may contain vast numbers of bacteria, even the bulk of them, as in bacteremia. They are not to be confused with septicemia, which is a constitutional condition produced by bacteria, whose action is for the most part local, but not necessarily pyogenic.

Cause.—As has been intimated before, certain bacteria are prone to produce spreading infections and septicemia, others may do so, and still others, poorly pathogenic and capable of invading tissues only when their resistance is reduced, would scarcely be able to cause a general hematic infection under the most favorable circumstances.

The bacteria most frequently recovered from the blood and viscera of septicemic patients are streptococci. In addition to streptococci, Staphylococcus albus or aureus, pneumococcus, Bacillus coli communis, Bacillus diphtheriæ, gonococcus, and several of the anaërobes, especially Bacillus aërogenes capsulatus, Bacillus typhosus, and Bacillus pyocyaneus, may be given as causes of septicemia. Some of these bacteria usually produce a disease, as, for instance, Bacillus typhosus and pneumococcus, but they may produce local and hematic infections as well, and show then not the characteristics of their specific disease, but a true septicemia. Proteus vulgaris has been recovered from the blood of septicemic patients.

Pathology.—The primary lesion may vary from the most insignificant scratch or prick—cryptogenetic cases are reported—to the most violent inflammatory processes. The atrium, in case it is a wound, may paradoxically enough show no reaction from the infection, and be healed in the few days that elapse before septicemic symptoms develop. This explains the so-called idiopathic septicemia. The conditions serving as atria of infection for septicemia are wounds, uterine infections following abortions and deliveries, abscesses, acute osteomyelitis, and erysipelas, together with lesions produced by the specific micro-organisms which occasionally or habitually result in a localized inflammation. A number of cases of suppurative inflammation of the thoracic duct have been described, usually unmistakably secondary to infections in the distribution of radicals in the pelvis, and the chyle vessels in the alimentary tract. A few cases of primary suppuration of the thoracic duct have been reported. It is superfluous to say that such a condition could scarcely fail to result in septicemia or pyemia. The only evidence so far advanced is the continuous increase of the leukocyte count to an enormous number, even as high as 200,000.

Entrance of Bacteria into Circulation.—From a surgical standpoint, by far the greater number of cases of septicemia result from the escape of bacteria from an infected wound, from decomposing blood-clots, or gangrenous tissues. Septicemia was a frequent complication of hospital gangrene before this disease was practically blotted from the list of surgical conditions. It may follow closely on the development of acute infections, which can be explained only on the hypothesis that bacteria have gained access to the blood, in all probability through the mucous membrane, and lodged at the site of an insignificant injury, as is illustrated by acute cases of osteomyelitis, which may terminate in a fatal septicemia before the local process has had time to suppurate. From the local infection the bacteria may invade the general circulation, either through the lymphatics or by escape into the blood-vessels, as happens when an abscess ruptures into a vein.

General Pathology.—The essential feature of the general pathologic picture of septicemia is that the blood contains the bacteria, a statement questioned by authors who believe that their appearance in the blood is accidental and inconstant, and that the fundamental pathology is the presence of numberless small, often microscopic, foci of infection scattered through the tissues by the blood, which is only the distributing medium and not the tissue primarily concerned in septicemia. The spleen is enlarged.

The infection in cases of septicemia may produce no lesion further than the cloudy swelling, or, if chronic, the amyloid changes and the hemolytic changes as described previously under Sapremia. On the other hand, frequently a septic endocarditis complicates the general infection, and produces local and general symptoms and signs in keeping with the changes produced in the valves of the heart. However, even in the most violent cases of septicemia the valves may remain normal. This endocarditis may affect either the mitral or the tricuspid valves, the former more frequently. Even in mild cases of septicemia the development of malignant endocarditis will add greatly to the unfavorable prognosis, but even with this complication some cases may not be hopeless. If miliary abscesses develop they appear in great numbers, and are found scattered throughout the body, in the marrow, bones, central nervous system, glands, and the abdominal and thoracic viscera. Again, the distribution of the miliary foci may be very partial, showing up in great numbers, for example, in the lungs and liver, and very slightly in other viscera. There is frequently a universal enlargement of the lymph-nodes.

The Blood-count.—A polymorphonuclear leukocytosis is usually present, although in the most severe cases it is absent. Mention is made above of the enormous count attained in suppuration of the thoracic duct.

Symptoms.—The interval between the date of primary infection and the development of septicemia varies from a few hours to several days. The facts can best be comprehended by remembering that usually a local inflammatory process precedes septicemia. The time required for this to take place then intervenes, and septicemia will, therefore, not develop as soon, on an average, after the primary infection as a sapremia would. Usually the time required is from forty-eight hours up. Still those rapid cases must not be forgotten in which at no time a primary inflammation develops, but the bacteria are delivered in the shortest possible time into the circulation. These, of course, would develop rapidly (occasionally in a few hours), and may run a fatal course in three or four days if the number of bacteria introduced is large. On the contrary, it is possible for a septicemia to develop at any time while there remains a suppurative focus in the body.

On observation of a patient who has septicemia the pallor, the listlessness, the yellowish cachectic appearance, the drawn features and the dilated nostrils, the rapid respiration, and the great emaciation are very striking. Septicemia quickly gives the patient the appearance of having been ill for a long time. The general appearance is that of great prostration. The eyes are sunken, the cheeks hollow, and the bony prominences stand out in undue relief; cyanosis is also often present and the patient is usually restless.

At the beginning the skin is dry and hot, and, as the disease advances, perspiration may take place, either a constant moisture of the surface, which gives it a cold, clammy, repulsive feel, or the perspiration may be drenching. In other cases the skin remains dry throughout. There appear at times various cutaneous eruptions resembling scarlatina, urticaria, or, it may be, a pustular eruption. Icterus may be distinct and petechiæ are often observed.

The Temperature.—As in all reactions caused by bacteria, the temperature rises in septicemia, frequently preceded by an initial chill, but by no means constantly. The chill is not likely to be repeated. The temperature rises gradually in those cases where the infection is brought slowly into the circulation, very rapidly in most acute cases in which large numbers of bacteria are admitted at once. The chart shows the temperature usually as a continued fever, with slight elevation of the evening over the morning temperature. High degrees are often reached, and in the worst cases a subnormal temperature is observed. In chronic cases the temperature may range from 99½° to 101° or 102° F., and continue many weeks without coming to normal. When conditions are present which might cause a septic intoxication or sapremia, and the proper local treatment fails to bring the temperature to normal or nearly so, it is very suggestive of hematic infection. In the course of a suppurative or infective process a persistent elevation of the temperature, after a satisfactory progress for some time, should stimulate an immediate investigation of the cause. As the condition improves there is a gradual subsidence of the temperature to or below normal.

Pulse and Blood-pressure.—Little disturbances of the pulse, beyond a slight acceleration, is observed in the mild cases, but in the severe forms the pulse is unduly rapid and the blood-pressure is low, as shown by employment of the sphygmomanometer or by the softness and compressibility of the pulse. High pulse-rate in proportion to the temperature is frequent in septicemia and is an ill omen, for it shows exhaustion of the cardiac centers. This combination finds its worst form in the subnormal temperature and the rapid, thready, often dicrotic pulse which can scarcely be felt or counted. The condition of the pulse and the loss of blood-pressure, together with the general appearance of the patient, are the most important symptoms of septicemia. The lips are parched and cracked, the tongue is dry, and sordes are found upon the teeth unless the course is very rapid.

Great thirst is present, which it seems impossible to satisfy. Nausea is present and vomiting may occasionally occur, or may be continual and violent. Certain cases closely reproduce choleraic symptoms. Anorexia is present, as in all septic conditions; it is complete in septicemia. Diarrhea is usually present and at times the motions contain blood. Involuntary passage of urine and feces is occasionally observed.

The urine is scanty and high colored, and contains albumin, often abundantly, and casts. The causative micro-organisms can often be discovered in it. In many cases pains of a cramp-like nature are present in the extremities, and there may be headache.

In prolonged cases of septicemia, decubitus must be constantly guarded against, as the tissues are poorly resistant, and the rapid emaciation brings the bony prominences close to the surface. The wound, if one be present, sometimes assumes almost distinct characteristics; granulations do not appear, and, if they were present at the beginning, are soon lost, and the surface of the wound is covered with a false membrane of necrotic tissue, intermingled with which is more or less fibrin. This is especially true of streptococcic cases. This necrosed tissue is yellowish, gray, or dark in color; suppuration is absent, or ceases if it has been present, and the surface of the wound is dry. In very acute cases little change of the appearance of the wound is noted.

Prognosis.—What the outcome of a given case of septicemia will be is problematic. All the rapid acute cases die, a few of the subacute get well, and the outlook is best of all in the chronic cases. One may briefly summarize the prognosis by stating that practically all untreated cases die, and that some recover if treated assiduously.

Treatment.—The prevention of septicemia is one of the surgeon's chief cares. Asepsis is the method of prevention in operative work, and, following as a close second, is the avoidance of accumulations of blood or serum which may become infected; this prevention is to be done by complete hemostasis or by drainage. Again, by the avoidance of injury to the tissues by undue tearing, laceration, or bruising the possibility of septicemia is reduced. All these favor infection, even under the most aseptic conditions. There is no place in modern work for the ignorant, heavy-handed, careless surgeon. Once again, the surgeon must ever be alert to see and quick to act upon conditions, usually hyperacute owing to intense bacterial virulence, which so frequently are complicated by septicemia, and to have the utmost care that a wound that was guarded with the most zealous watchfulness during the operation is not infected at some subsequent dressing, by some careless nurse or assistant or by himself. Too frequently, indeed, surgeons do not surround their after-treatment with the same judicious restrictions that are used in the operating room. The use of dilute tincture of iodin on the tissues at each dressing is perhaps the surest guarantee against a late infection. The acute conditions demanding prompt action are particularly acute osteomyelitis and epiphysitis, especially in the young; middle-ear infections and suppuration, or even non-suppurative inflammation of the mastoid cells; acute, virulent infection of the uterus and the adnexa and thrombophlebitis, especially affecting the large pelvic veins or the cerebral sinuses or veins tributary to them. Acute suppurative peritonitis, spreading traumatic gangrene, and microbic gangrene following compound fractures should be included in this dangerous list.

The details of treatment for these various conditions would lead us too far afield into general surgical treatment. But whether septicemia has already developed, or the intention is to prevent it, two fundamental items of treatment must be utilized, namely, the removal of the infected focus completely, if not prevented by the patient's general condition and by the location and extent of the focus; and, second, such treatment by drainage, ligation, etc., as will render the escape of bacteria into the blood less likely, or, if they have already begun to enter, to check the process in *statu quo*. Fearless and extensive surgical measures, in keeping with the general condition of the patient, are more urgent here than in any other pathologic condition, malignancy alone excepted. Remove if possible; if not, then create a drainage current away from rather than toward the circulation. The local use of antiseptics is indicated where they can possibly be applied. Carbolic acid and bichlorid and alcohol are the favorites, but it is difficult to see of what value they can be beyond the immediate surface of application.

The general treatment of septicemia is directed along very definite lines, but the means at the surgeon's command are limited both in application and in efficiency. The aim of treatment is to *eliminate the bacteria and their toxins as rapidly as possible*, to *destroy the bacteria or neutralize their toxins in the blood*—*i. e.*, to render the blood sterile—and, *finally*, *to maintain the patient's vitality* until such results can be effected.

The elimination of toxins and bacteria must be done chiefly by the administration of water; therapeutic and other measures to produce diaphoresis and purgation are too prostrating to be attempted, so water by rectum and by mouth, and intravenous or subcutaneous injection of normal salt solution, is the chief reliance.

The destruction of bacteria and neutralization of toxins is successful to a limited degree, dependent largely upon the specific micro-organisms and upon our ability to determine what species the infection belongs to. If a mixed infection is present, any specific treatment would at most go only half-way toward cure. If a diphtheric septicemia is to be treated the specific antitoxin is ideal, unless too great advances are made before using it. In case of streptococcic septicemia the results are less happy, owing to the great number of varieties of these micro-organisms and to the practical worthlessness of a serum adapted against one variety in the treatment of another. Antistreptococcic serum should always be used in streptococcic infections, but it cannot be used with the same assurance as if one knew the variety both of the infection and of the serum. The serum should be used at the earliest possible opportunity, and should be repeated daily or twice daily, giving from 10 to 15 c.c. at each sitting, or in larger doses at wider intervals, depending upon the results obtained.

If the cause (bacterium) is recognized, it is well, especially in the chronic cases, to administer specific vaccines; if it is impossible or impracticable to determine the cause, autogenous or polyvalent vaccines are to be tried.

Direct Transfusion and Antiseptics, General Treatment.—Direct transfusion of blood should be resorted to in the subacute and chronic cases, but can offer little hope in violent acute septicemia, as, indeed, all remedies do.

Very naturally, the direct injection of antiseptic solutions into the general circulation suggests itself as a rational treatment of septicemia, and experimental and practical work has been done along this line, but with such varying reported results that one can scarcely estimate the true value, except to state that it is far below the hope created by the suggestion.

Collargol, 10 c.c. of a 2 per cent. solution, nitrate of silver, 1 to $1\frac{1}{2}$ grains in a pint of water, and a maximum 50 c.c. of 1 : 2000 solution of formaldehyd, while occasionally giving apparently brilliant results, do not prove of value in more than a small percentage of cases, and, while their use may be recommended, they do not offer a very sanguine prospect of cure.

PYEMIA[1]

Pyemia is a general septic condition characterized by the presence of metastatic abscesses.

Cause.—While certain non-pyogenic bacteria may exceptionally be responsible for septicemia, the causative bacteria of pyemia must obviously be pyogenic. And of these pyogenic organisms the chief ones must be named as streptococci and staphylococci. There is, aside from the pyogenic qualities of all bacteria causing pyemia, no difference between the etiology of septicemia and pyemia, and cases are seen in which the first period of illness is clinically a septicemia, and suddenly, without invasion of additional bacteria, the picture changes to that of typical pyemia.

Pathology.—Since any case of septicemia may become one of pyemia, the same statements obtain here that were made in discussing the local condition in the former type. The primary lesion is a gross lesion, and will usually be discoverable if searched for.

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[1] The so-called septicopyemia differs in no essential respect from pyemia.

The general pathologic changes are the same in pyemia as in septicemia. Bacteria may be present in the blood and are deposited from the blood; it is immaterial. But abscesses form in the former condition, and determine the essential difference between the two types of sepsis. These abscesses are not all of the same age, but, while one has matured, ruptured, and is healing nicely, others of all grades of development are to be seen. This, of necessity, depends on whether the emboli all lodged at about the same time or continued to enter the blood and lodged at intervals of some days.

Symptoms.—The necessary time intervening between the date of local infection and the development of pyemia is longer than in either of the preceding types. Here the local infection must occur and advance sufficiently far to produce suppuration or disintegrating thrombi, although pyemia occasionally develops before local suppuration occurs, and when the emboli enter the circulation and lodge they must have sufficient time to cause inflammation and abscess formation. Hence, from the date of the local infection to the manifestation of pyemic symptoms would be several days, from five to seven, as a rule, or at any subsequent time.

The beginning of pyemia will show some discomfort and malaise, with a slight rise of temperature. This is a kind of prodromal stage which will often escape notice; even if observed it could not be called pyemia. The real beginning of pyemia is usually a chill, frequently a prolonged one. This is followed by a rise of temperature, often to very high degrees. The initial chill is occasionally wanting. The general course of the temperature, chills, and sweating is that of pus absorption in its most intensified form. There is no regularity of these symptoms, and this irregularity constitutes the essential significance of the pyemic chart. Malaria and typhoid usually follow a definite course; pyemia almost never; no two charts are alike, but nearly all of them indicate pyemia. The fever is remittent or intermittent, and the time of occurrence of these alterations of temperature cannot be foretold. There is a chill, a rise of temperature, which may remain high for a time, or begin at once to drop and soon reach normal or subnormal. These excursions may be repeated several times a day, there may be high temperature in the morning and a lower at evening, or *vice versa*. A chill may occur every day or every other day, and the course of the disease simulate malaria. Occasionally it is difficult to differentiate pyemia from typhoid. Sweating occurs; the skin may be dry at the beginning, but when the chills come the skin is constantly moist and the sweat is often colliquative; usually the sweats are worse after the chill and accompany a drop in the temperature.

The pulse does not show the same cardiac exhaustion as in severe cases of septic infection or septic intoxication and sapremia. The pulse-rate increases with the rise of temperature and returns to or near normal as the fever subsides. The blood-pressure is likewise not much reduced in the beginning. In the violent acute cases, when general exhaustion comes on, the pulse becomes gradually more rapid and weak, and the arterial tension shows continual reduction. The same general symptoms of headache, backache, pain in the extremities, malaise, dry, coated tongue, thirst, loss of appetite, nausea and vomiting are seen as in all other severe intoxications. Diarrhea is often present, and depends for its origin on the same factor which produces it in septicemia, or on the presence of metastases in or near the intestinal tract. Diarrhea nearly always is present in the late stages and is very foul. Icterus is neither constant nor early, but it may appear after the red cells are disintegrated in large numbers or after the liver is sufficiently involved in the pathologic process.

The mental condition is less exaggerated in pyemia than in septicemia. The drowsiness, somnolence, and stupor of the latter are not present in pyemia. Consciousness remains to torture the patient with his serious plight. Delirium may appear during the high elevations of temperature. Later, when exhaustion is severe, and the poisons have long affected the overworked nervous system, delirium, stupor, and coma may succeed each other. Still one will often see cases of pyemia remain conscious until the very last moments of life.

The presence of endocarditis, which here is suppurative or ulcerative, is observed in from one-fourth to one-fifth of all cases, usually affecting the mitral valves, but occasionally the tricuspid.

With all the above symptoms and with the changes observed in the blood, namely, increased leukocyte and reduced red blood-count, with or without the presence of micro-organisms in the blood, the diagnosis of pyemia, however suspicious, remains to be confirmed only by the discovery of secondary abscesses. These abscesses may be few or many: they may be superficial and easily discernible or deep and defiant of positive recognition.

The location of metastatic abscesses depends on the site affected by the primary lesion. The organs most frequently containing metastatic abscesses are the large viscera, thoracic and abdominal. The lungs stand at the head of the list; the venous blood from the general circulation passes the first set of capillaries here. The liver stands next; the portal blood passes through a capillary circulation in this organ. The abscesses may be confined largely to one organ or pair of organs, or they may be distributed *ad libitum*, affecting every structure from skin through t mucous membrane. Metastases in the brain are rare. A fe large abscesses may be found or multitudes of small ones, or the may vary through all sizes.

The presence of metastatic abscess in cases suspected of pyem should be sought for with diligence, only repeated complete ph ical examinations sufficing; for, while in one structure they ca marked symptoms and in another none, in a third they vary, n showing evidence of their presence, again showing none. Wh abscesses attack the lungs the fact is perhaps indicated by respi tory disturbances and physical signs, such as consolidation fr pneumonia gives. Multiple abscesses give clinical signs resembli catarrhal pneumonia. If the abscess is situated close to the pleu evidence of pleuritis is found, and there is danger of rupture i the pleural cavity and causation of pyothorax; or, if near bronchus, rupture causes expectoration of pus, which is oft malodorous. Rupture may occur into bronchus and pleural c ity at the same time, and cause a sudden pneumothorax, whi produces alarming symptoms and later pyopneumothorax.

When the liver is affected, diagnosis cannot be made early, a if the abscesses are situated deeply, they may continue undisc ered. The occurrence of diarrhea and the appearance of pus pus and blood in the stools points to intestinal involvement. T spleen, already enlarged in the course of the disease, though frequently attacked, offers great difficulty in diagnosis if absc occurs. Involvement of the kidneys may occur without eviden or an acute nephritis may be present, with clinical and urin evidence. The osseous system, the joints, and the soft structu offer fewer difficulties, and show evidence of acute inflammat involvement or of suppuration.

Prognosis.—The acute cases of pyemia run a rapidly fa course, and are, practically without exception, uninfluenced treatment. Chronic pyemia lingers long, often being protrac for months, and a few cases of this type end in recovery.

Treatment.—Pyemia is to be treated along the same lines septicemia. The only additional item is the abscesses that co up during the progress of the disease. They must be watched and all suspicious symptoms investigated thoroughly. As t abscesses develop they are treated according to the plan alrea given.

CHAPTER VII

GANGRENE

GANGRENE is the death of macroscopic portions of tissue or "the death of tissue *en masse*."

There are several synonyms. Mortification is practically identical with gangrene, but is also used to signify the decomposition of tissue occurring at death. Necrosis is death of bone tissue, and sometimes refers to death of a viscus or a portion of a viscus. Mummification is dry gangrene. Sphacelus is gangrene and putrefaction of an extremity. It further means the gangrenous mass of tissue.

The Etiology of Gangrene.—All cases of gangrene may be attributed to one of two fundamental causes—viz., inability of the tissues to give a sufficient supply of nutriment, or their inability to assimilate nutrition when it is brought to them, or to a combination of the two. In the former instance the cause is circulatory, and may be applied at the site of gangrene or more or less remote from it. In the latter it is due to devitalization of the cells, so that they are killed at once or so crippled that they cannot maintain their existence. It is self-evident that in injuries sufficient to devitalize the tissues completely or incompletely the local vascular supply will be more or less crippled. This fact needs to be made clear, namely, that an injury to the tissues may occur without gangrene, or a crippled circulation may exist a long time without its development; but in either instance coincidence of the other factor cannot be withstood. So that either of these conditions may serve as a predisposing and the other as the exciting cause. A crippled tissue may continue to live on a full blood-supply; healthy tissues may continue to live on a crippled blood-supply; but either condition, complicated by the other, may immediately cause gangrene. The importance of these two items will be seen in prophylactic treatment.

Inadequate Blood-supply.—Complete interruption of the circulation through a part for a short while (often in a few hours) is certain to produce gangrene. Further, when the blood-supply to the part is diminished below the minimum required to maintain vitality gangrene must result, but slowly, the rate of development being in direct ratio to the reduction of circulation. This interference with the circulation may occur either in the arteries or the veins, and may be sudden or slow and complete or incomplete. The predisposing causes of gangrene are particularly those conditions that reduce the efficiency of the general circulation and reduce the vital activity of the cells; an illustration of the former is poorly compensating heart lesions, and of the latter, diabetes mellitus.

To illustrate the importance of circulatory obstruction in gangrene a few of the more usual disturbances are given. A very frequent interference with nature's delivery of sufficient quantities of blood to the tissues is found in arteriosclerosis, which narrows the lumen and reduces the elasticity of the vessels. Embolism and thrombosis, the former in arteries, the latter in veins, are quite often responsible for gangrene. Ligation of the main artery or vein of a part when an insufficient collateral circulation can be established, or when the collateral vessels have been injured by undue trauma to the tissues, cause it. An occasional example is seen in gangrene in the base of the bladder where a radical hysterectomy for malignancy has been done. Then, too, obstruction afforded by extravascular lesions, as tumors, cysts, and inflammatory products, finally by vascular spasm, whether due to pathologic or to therapeutic causes. In all conditions, as in various forms of hernia and in torsion of the viscera, the circulation may be stopped by a constriction ring or by the twisted pedicle, and either the venous circulation may be cut off alone or in conjunction with the arterial. In cases where these conditions are *per se* incapable of producing gangrene, the reduced blood-flow serves as a powerful predisposing cause when local causes are added. An illustration will elucidate this. Suppose a case of strangulated hernia. The vital support is almost entirely cut off; trauma is added by violent efforts at reduction, and infection is added from the lumen of the gut, causing gangrene.

The local causes of gangrene cannot act on the tissues extensively without involving the local circulation, and so circulatory obstruction is almost invariably associated with cell destruction. In this way a smaller danger will result in gangrene if the small blood-vessels could be spared. These local causes are the same as those mentioned under the etiology of inflammation as exciting causes, with possibly the exception of electricity. In the inflammatory processes the causes were applied with sufficient intensity or duration to call forth a defensive reaction of the tissues, but in gangrene the tissues are so crippled that they cannot react or can react only inefficiently, or they are killed outright or partially by the particular injury done. Heat, cold, chemicals, especially the escharotic drugs, traumatism, and infection may independently cause gangrene. It is manifest that the first four will cause a localized gangrenous process unless there are local or predisposing causes to favor spreading gangrene. Infection may cause a gangrene coextensive with or less than the extent of the infected area; it often causes a spreading gangrene, and, when combined with one of the other causes of this group, particularly trauma, as is usually the case, it is capable of producing rapid and extensive gangrene almost before the surgeon has suspected its presence.

Dry and Moist Gangrene.—Before taking up a study of the various types of gangrene a fundamental clinical division of the condition into two types must be noticed, namely, dry gangrene and moist gangrene. The essential difference between the two conditions is that in dry gangrene circumstances have favored the evaporation or absorption of fluids from the tissues, and perhaps at the beginning prevented engorgement of the vessels with blood and the tissues with edema; while in moist gangrene circumstances have produced an effect exactly opposite. In other and plainer words, a gangrene that develops slowly enough for the tissues to dry out meanwhile is dry; rapid gangrene is always moist. Sudden and complete blocking of the arterial supply or blockage of the venous return, whether complete or partial, causes moist gangrene; incomplete blockage of the arteries causes dry gangrene; infective gangrene is always moist. The time required determines, more than any other factor, whether the gangrene is dry or moist. It is, of course, unnecessary to state that internal gangrenous or necrotic tissues are never dry; there is no possibility of evaporation.

The appearance of dry gangrene is characteristic. The tissues are shriveled and shrunken. The part is much smaller than normal and is cold. The gangrenous mass is spoken of as mummified. The cutaneous surface has a brown, black, or yellowish color, and is often likened to the rind of smoked bacon. There are no blebs, no blisters, and if they were present at the beginning they disappear; infection cannot attack the dry, hard tissues except where a line of demarcation admits infection between the living and the dead tissues; consequently there is little or no malodor in dry gangrene. Dry gangrene occurs with far the greatest frequency in the old, in whom arteriosclerosis is present, whatever the cause of it, with an ever-increasing gradual reduction in the blood-carrying capacity of the arteries, and an undiminished opportunity for the escape of the blood through the veins whose caliber has not been altered. It occurs where an embolus partially blocks the main artery, and where a prolonged and incomplete angiospasm is produced by the long-continued use of ergot and in Raynaud's disease. Gangrene resulting from severe burns and from frost-bites is frequently dry, and diabetic gangrene may be dry. Gangrene of the finger-tips, ears, and toes is usually dry when it is confined to these structures.

Moist gangrene presents different phenomena. Here the tissues are swollen, they are larger than normal, and blebs appear beneath the cuticle and are filled with a serous fluid; it is often sanious. These blebs may be moved from place to place by pressure, and gravitate to the lowest level in any position, a distinction from the blebs found in burns. The tissues are edematous and boggy; they contain an excess of fluid. The cuticle is easily stripped off, and thus an atrium of infection is afforded. The color

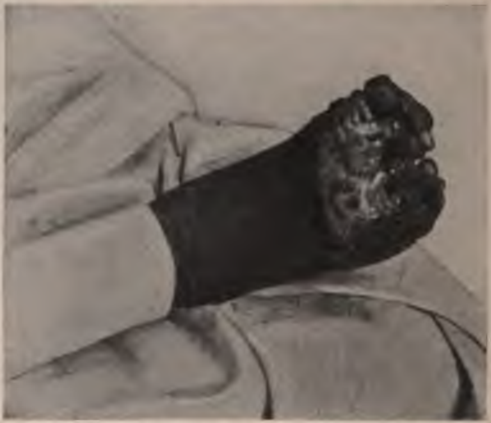

Fig. 29.—Moist gangrene from frost-bite.

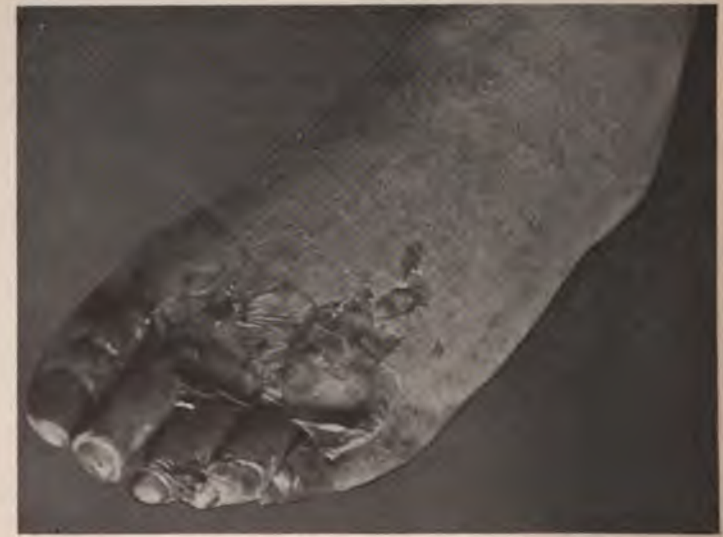

Fig. 30.—Moist gangrene. Senile.

varies even in the same case; the color at the beginning is bluish or purplish-red, and, as the condition advances, the color becomes brown, black, or mottled; other colors are noted occasionally, as is illustrated by the greenish appearance resulting when hydrogen sulphid is liberated in the decomposition of the parts. The odor is foul, and is the same as that of postmortem decomposition; if no infection is present, which is a rare exception, there will be no malodor. The odor is due to the formation of sulphuretted hydrogen, butyric and valerianic acids, ammonia and skatol, besides many other unpleasant compounds. When one imagines a combination of the above list of foul-smelling products it becomes superfluous to comment further on the odor. Gases may accumulate in the gangrenous and even adjacent tissues as a result of gasogenic infection. Then crepitation becomes an important and ominous sign. As the process continues decomposition advances, and the parts are so completely changed that they drop away of their own weight.

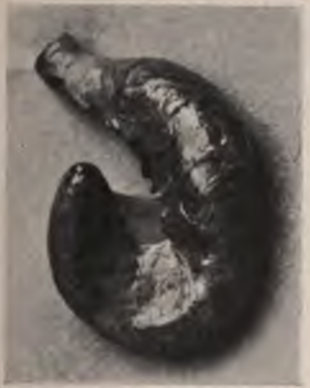

Fig. 31.—Gangrenous appendix fifteen hours after first attack.

Pain as a symptom in gangrene is very variable. It may be present from the beginning and remain, being kept up by the advance of the process on to living tissue. In cases of limited gangrene the pain ceases when the tissues die, but, as long as they live and are feeling the need of unsupplied nourishment or the irritation of deadly poisons, the pain is intense. In gangrene due to embolus the pain is felt in the whole of the region deprived of blood and is often violent. Pain from this source may be referred, just as in other conditions.

An important precaution is to be pointed out here; in all those conditions, obstructive or inflammatory, where gangrene is capable of developing, as in appendicitis, cholecystitis and strangulated hernia, and intestinal obstruction generally, in which, from the patient's view-point, the pain is the most important symptom, and where cessation of the pain in a brief time without anodynes would mean that the part has become gangrenous, the administration of anodynes, accompanied with non-surgical treatment, should be recognized as a most injudicious and dangerous practice. However much surgery may have been indicated before such sudden cessation of the pain, it is absolute and imperative afterward, and this indication will be lost if the one most important symptom is eliminated by a dose of morphin.

Line of Demarcation.—There is frequently a definite line marking the border between the living and the gangrenous parts. It is known as the line of demarcation. It is rarely a regular, even line, but is uneven, reaching higher levels on one aspect than on another, and may be broken, extending, for example, only partially around an extremity. It marks the level at which the tissues are able to withstand the gangrenous process, at which the blood-supply is able to take care of the cells, or the cells able to maintain themselves; at which separation of the living from the dead tissue will take place, if at all. On one side of this line the tissues were not sufficiently crippled to lose their vitality, on the other they were too badly crippled to maintain it. It is at this level that self-amputation occurs, if at all. At the line of demarcation, when separation occurs, there is usually a purulent or seropurulent discharge, and the living tissues immediately above the line of demarcation show an inflammatory reaction due to the bacteria that have gained admission.

General Symptoms.—Gangrene may exist without the presence of constitutional symptoms, or they may be present in all gradations, from the mildest to the most violent; the symptoms are of the sapremic type. In cases where the gangrene is caused or predisposed to by a constitutional disease the symptoms of the former are superadded to those of the latter. The general symptoms are least marked in dry gangrene, more marked in moist gangrene, and most intense when the latter is caused by infection. On the other hand, mild constitutional symptoms are sometimes observed in gangrenous conditions which are not infected.

Senile Gangrene.—This term is applied to gangrene caused by senile changes in the arteries, namely, arteriosclerosis and atheroma. However, the conclusion must not be drawn that a certain age must be reached before senile gangrene may develop; for, although this type of gangrene is usually seen in individuals past fifty years, arteriosclerotic changes may develop in comparatively young individuals and favor its appearance in them.

Admitting the presence of arteriosclerosis and the consequent prolonged and gradually increasing malnutrition of the tissues, the appearance of senile gangrene is usually attributed by the patient to trauma, which, under ordinary circumstances, would be insignificant, such as a slight bruise, the pinching of a toe by the shoe, an ingrowing nail, trimming a corn, or a hang-nail. Diminished heart action is very favorable. Thrombosis of the small blood-vessels or embolism of the arteries are additional causes. Pain may be very severe or insignificant. One sees cases of gradually extending senile gangrene without apparent evidence of discomfort. The slight injury that serves as the starting-point of the gangrene is usually extraordinarily painful. Senile gangrene is usually dry, but it is occasionally moist; it is usually seen affecting the lower extremity, beginning in one or more toes; it is rarely seen in the upper extremity. The presence of pain in a toe, with no adequate explanation, in an individual of advanced age who has

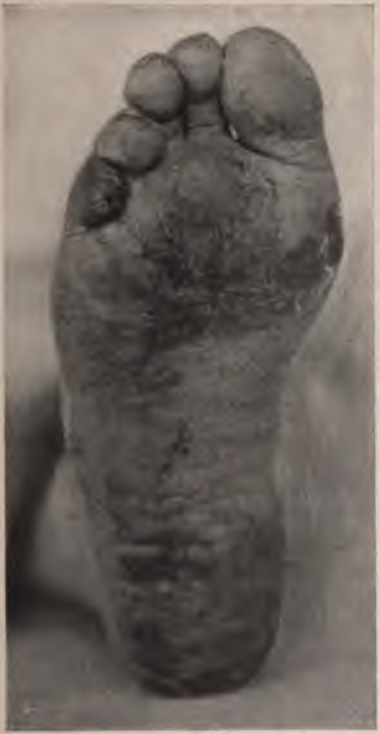

Fig. 32.—Senile gangrene in little toe and just beginning in the fourth toe. This patient's other leg had been previously amputated for the same condition.

hard arteries, should not lead one to make a diagnosis of gout, as is often done, for a little care will clear up the matter, as when the characteristic discoloration, purplish or bluish, appears at the painful spot the real cause may be decided upon. As soon as the tissues necrose the pain ceases and the general comfort remains undisturbed, provided the process is not advancing. The advance of the gangrene may be checked by a line of demarcation at the metatarsophalangeal articulation, and the toes become dry and black and hard; or the tissues may be unable to resist the advance, and the gangrene gradually extend on the foot and to other toes. The outlook is much less hopeful when self-limitation has failed to occur at the base of the toes. If infection gains admission, as is frequently the case, the living tissues adjacent to the border become inflamed, and this reduces the efforts at demarcation and favors a further and more rapid extension. Occasionally the gangrene extends well up the leg, but, as a rule, these patients die of sepsis or exhaustion before the leg is materially involved. Extensive crippling of the large vessels of the leg favors extension of the gangrene to the leg.

More rapidly developing cases of senile gangrene are those due to the lodgment of emboli at the bifurcation of the popliteal artery and those in which thrombosis of the main vessels of the leg occurs. In such cases the pain is more extensive, often violent, and, in case of embolism, very sudden. The primary appearance of discoloration is of wider extent and the extremity becomes cold. The pulse is absent from the vessels of the affected part. The gangrene extends from the parts receiving no collateral circulation upward until a level is reached which has an adequate blood-supply. If thrombosis affects the femoral vessels, there is no limit to the advancing gangrene and the prognosis becomes hopeless.

Spreading Traumatic Gangrene, Fulminating Gangrene, Gangrene Foudroyante, Gangrenous Emphysema, Microbic Gangrene.—The behavior of these gangrenous processes is so similar that they may all be treated under one heading. They are all caused by bacteria; they are usually preceded by a more or less severe injury. The injury may *per se* cause a definite extent of gangrene; the spread is invariably due to the bacteria.

Spreading traumatic gangrene is seen usually following severe contused and lacerated wounds and compound fractures which have been infected at the time of injury. The infection begins at the atrium and spreads rapidly, causing thrombosis of the veins and necrosis of the tissues. Gas may be produced, and when it is, recognition of its presence is made by the discovery of crepitus, which is interpreted as meaning that the infection has spread to that level.

The surface of the wound may appear perfectly normal, and even when the skin is involved the extent of this involvement cannot be accepted as the measure of gangrene of subcutaneous structures, and, therefore, is a worthless index as to the point at which removal must be done. The first evidence of this type of gangrene is that the infection causes a rise of temperature, or it may be the discharge of a foul-smelling fluid, serous or sanioserous, from the wound; the escape of such fluid should lead to a thorough investigation without delay regardless of surface appearances.

The constitutional symptoms are those of an intense infection and belong to the sapremic type (*q. v.*). The violence of the symptoms may be understood from the fact that it is the most rapidly fatal type of gangrene known; death may come in four or five days from the date of infection.

The presence of emphysema only adds to the gravity of the condition, as the tissues are loosened by the gas-bubbles and an easy spread of the infection thereby becomes possible.

The prognosis is always grave and, unless the most active treatment is instituted early, it is certain to terminate fatally.

Diabetic Gangrene.—Diabetic gangrene is observed coming up in the course of diabetes mellitus. Frequently the gangrene directs attention to it. The cause of it is found in the general loss of vitality of the tissues in such cases, but the fact that arteriosclerosis of the vessel supplying the gangrenous region is found in the majority of cases has caused many pathologists to consider this the chief cause; some consider it the only cause. There can be no doubt, however, that diabetes of itself favors the occurrence of gangrene. Diabetic gangrene may originate without apparent outside provocation, but, as in other types, the occurrence of a slight injury in favorable subjects often serves as a starting-point. Gangrene usually begins in the little or big toe, and the majority of cases affect the lower extremity. Occasionally other parts of the body are affected, as the buttocks, hands, face, neck, or external genitals. The lungs are rarely affected. Diabetic gangrene may appear in a single primary focus, or there may be multiple foci appearing at about the same time, followed subsequently by other gangrenous areas, until the lower extremities are mottled with dark patches. It is dry or moist, and, so far as the appearance of the gangrene and its clinical behavior is concerned, cannot be distinguished from other types until the recognition of the causative constitutional disease determines its nature. A line of demarcation may form, but the poor vitality of the tissues together with the reduced blood-supply may be so marked that no line will form.

Diabetic patients are always poor surgical risks, and only the most serious and urgent demands justify surgical treatment, major or minor. The additional presence of arteriosclerosis demands even further precaution, for instead of normal healing gangrene may develop. After removal of the gangrenous part one can only hope that the process will not be re-established at the line of incision, even when this is made remote from the original gangrenous area. It is claimed that removal of the gangrenous tissue causes a temporary reduction in the output of sugar.

Prognosis.—The prognosis of diabetic gangrene is extremely bad.

Symmetric Gangrene, Raynaud's Gangrene.—Raynaud's disease is a condition which depends for its cause upon some central or reflex disturbance of the vasomotor nerves, which causes prolonged symmetric angiospasm. The arterial contraction has been demonstrated in the retina of a patient who had a concomitant disturbance of vision. The parts affected are usually fingers or toes, but the cheeks, nose, buttocks, and other regions may be affected. The condition is found in women in 80 per cent. of the cases, and these are usually between the age of eighteen and thirty years. Exposure to cold is usually the exciting cause, although it appears at seasons of the year and under circumstances such as to eliminate this element practically from the etiology. Raynaud's disease may be acute or chronic, and is seen more often in thin, poorly nourished, nervous individuals. Similar conditions occur rarely in the course of such affections as syringomyelia, multiple sclerosis, tabes, and tumors of the cord. There are three stages of the disease:

(1) Local syncope, during which the part becomes cold and pale, and assumes a waxy appearance. This stage may come and go, resulting in numbness, pain, and stiffness during the attack, followed by a return to normal. One not infrequently hears a layman refer to his "cold finger" or toe, and occasionally sees the condition in young women subsequent to a cold bath.

(2) Local asphyxia, in which the part becomes blue or cyanotic. The pallor is replaced by a bluish discoloration, which disappears under pressure and slowly returns on removal of the pressure. The color may increase until the part becomes almost or quite black. Blebs form over the areas most intensely affected, and later rupture, allowing the escape of a serous or seropurulent fluid. Pain is often intense during this stage, and the condition either begins to improve, the raw surfaces heal, the pain subsides, and the discoloration disappears, leaving the finger withered and flattened, only to recur again and again for a few years; or in any attack it may go on to the third stage.

(3) Raynaud's, or symmetric gangrene, in which the cyanotic

portion partially necroses, and becomes dry and hard and black; the gangrene usually affects the last phalanx of a finger or toe, sometimes of several, and it rarely extends further in a proximal direction than the base of the digits. The gangrenous area is not coextensive with the cyanotic area, and it is impossible to say in a given case what the limits of the gangrene will be. Inasmuch as the disease is self-limited, hasty removal of the parts need not be undertaken. A line of demarcation occurs, and frequently self-amputation and subsequent healing is seen.

Raynaud's disease has been mistaken for gout on account of the pain affecting the toes and fingers, but observation of the conditions present, a correct history, and the character of patients in whom the two conditions appear should prevent frequent occurrence of this error.

Symptoms.—The constitutional symptoms are negligible.

Prognosis.—The prognosis for life is good, and, under proper treatment and not too hasty removal of the parts, is better for the structure affected than the first appearance would indicate.

Ergot Gangrene.—This type of gangrene is rarely seen now-a-days, but was very frequent in the seventeenth and eighteenth centuries. It resulted from chronic ergot-poisoning, produced by eating bread made from rye. Rarely a case is reported from prolonged administration of the drug for therapeutic purposes. It causes spasms of the blood-vessels and acts similarly to Raynaud's disease—the digits are usually affected, especially the toes, but the gangrene may involve a hand, foot, or whole extremity. The initial symptom is pain, then pallor of the part; coldness, numbness, or anesthesia follows. Formication is often complained of. If the case is severe the local changes may be associated with constitutional symptoms of ergotism. Following the stage of pallor a dilation of the blood-vessels occurs, the vessels are filled with blood, the part becomes cyanotic, and gangrene supervenes; it is dry or moist, dependent upon the rapidity of development. Examination of the gangrenous part shows the vessels filled with clotted blood. In the slower cases a line of demarcation develops and self-amputation may follow, but in the extensive, rapid cases there is no line of demarcation.

Hospital Gangrene.—This type of gangrene produced extensive ravages in preantiseptic days, but is so rare now that few living physicians perhaps have seen a sufficient number of cases to be well acquainted with it. It has occurred more especially in times of war and under bad hygienic surroundings, such as obtain in crowded hospital wards. It is of an infectious nature, but no particular micro-organism is held accountable as the causative agent, and it is probably produced by different bacteria, often in mixed culture. When once it gains entrance to a hospital ward it can be communicated to other patients by direct transmission. Where strict asepsis can be maintained other wounds are in no danger. However, isolation is required, and the nurse who attends this disease must not be permitted to make other dressings.

Ordinarily, granulations serve as a barrier to infection, but the rule fails in hospital gangrene, for new wounds, granulating wounds, and even recently healed wounds all fail alike in withstanding the destructive advance of this dreadful condition.

The period of incubation is very short, and varies from less than twenty-four hours to a few days.

The constitutional symptoms are those of an infection. Ther may in severe cases be a chill—the temperature rises, as a rule, bu may remain normal or subnormal. The pulse is accelerated an the general condition is worse than the temperature-chart woul indicate. Prostration is great in severe cases.

The local condition is described under three types: (1) The croupous or diphtheric. (2) The ulcerative. (3) The pulpy.

(1) The diphtheric type begins by the appearance of necroti spots on the granulating surface and the formation of a false, o diphtheric, membrane over the wound, and the disappearance o granulations and necrosis of tissue underneath the membrane. There is an ichorous discharge of limited quantity, the odor of which is foul. The surrounding edges are slightly inflamed. This is the mildest type.

(2) The ulcerative type, similar in appearance to the first type, is more serious, and spreads into the surrounding tissues in an insidious manner, often extending far under the surrounding skin. The discharge is more abundant and the constitutional symptoms more severe. The edges are clean cut and surrounded by an inflamed zone.

(3) The pulpy type, the most severe, causes a distinct gangrene. There appears a thick membrane of a dirty gray or yellow appearance. This is at first dry. When it is removed no granulations are seen, but instead a raw, bleeding surface. The surface soon changes, and a large quantity of foul-smelling discharge results. The tissues are converted into a bulky, pulpy, gelatinous mass which often contains gas, and hemorrhages are likely to occur and recur. They are exceedingly difficult to control, and if from a large vessel are apt to terminate fatally, for the vessel walls are destroyed by necrosis and will not tolerate application of forceps or ligatures. The advance of necrosis is rapid, and no tissue is spared. The surrounding tissue is swollen, inflamed, and edematous. The constitutional symptoms are intense. Septicemia is a frequent complication.

In all types of hospital gangrene, when the necrotic tissue sloughs away or has been removed and granulations cover the surface, recurrence may take place at any time prior to complete healing of the ulcer.

The prognosis of hospital gangrene is bad; in the worst epidemics the mortality has exceeded 80 per cent.

Gangrene Due to Infection by the Bacillus Aërogenes Capsulatus.—So many cases of gangrene due to infection with Welch's bacillus are being reported in current literature that it is necessary to discuss it in this connection. The close relationship existing between this type of gangrene and hospital gangrene cannot fail to be noted.

Bacillus aërogenes capsulatus, belonging to the flora of the human alimentary canal, rarely produces infection because of two facts: (1) Because under ordinary circumstances it is slightly pathogenic, although when transmitted from an infection of human tissues it is exceedingly virulent. (2) Because it is an anaërobe.

The period of incubation for Welch's bacillus varies from eight hours to seven or eight days. It is usually between two and six days. The regions most frequently infected are the perineal region and the abdomen, especially in connection with perforative peritonitis; the subcutaneous fat seems to offer an especially inviting field. Of 4 personally observed cases, 2 were in the subcutaneous fat following operation for perforative appendicitis. The local signs cannot be distinguished from those of an ordinary inflammation until gas formation and crepitus occurs. The appearance of crepitus should at once arouse suspicion of this bacillus. It is probably the cause of the majority of inflammations associated with gas production. The gas is inflammable. It may not appear, owing to the presence of a mixed infection, and here it may be stated that Welch's bacillus is often enabled to attack human tissue by virtue of the presence of a symbiotic aërobe. Welch's bacillus is non-pyogenic; therefore the presence of pus argues mixed infection. It is often associated with colon bacillus, and may lead to the diagnosis of fecal fistula, owing to the presence of gas and the characteristic odor. When a wound is infected with Bacillus aërogenes capsulatus the subcutaneous tissue first becomes necrotic, and the skin edges of the wound, although apparently healing well, can be easily separated, and the subcutaneous fat is found to be already necrotic and grayish or yellowish black, and, if they are left alone for a time, it soon becomes semigelatinous and easily broken up. The skin or mucous membrane becomes involved, and the process gradually spreads, sparing no structure. Consequently, hemorrhage is likely to occur; if a mixed pyogenic infection occurs the appearance is that of a phlegmonous suppuration.

The constitutional symptoms are in no way characteristic, and may be briefly comprehended in the statement that they are such as would be produced by a septic intoxication. They may be mild or violent, but this variance cannot be considered a safe index to the prognosis. There is rarely an initial chill, but this is likely to occur if there is a mixed pyogenic infection. The temperature ranges from 100° to 104° F., or with subnormal registration in violent intoxications. The patient is weak and anxious, the pulse rapid, small, and soft. The remaining symptoms cannot be distinguished from those of ordinary infections.

The prognosis is unfavorable, as the average mortality is about 50 per cent.

Noma, Cancrum Oris, Cancer Aquaticus.—This is an infective gangrene occurring in the cheek and the external female genitalia. It is comparatively rare. Noma is seen usually between the ages of two and twelve years, rarely in older individuals. The predisposing cause is poor vitality, such as is seen so often in the children of crowded tenement districts whose surroundings are entirely bad. It may follow the infectious diseases, as scarlet fever, measles, typhus, or diphtheria. Occasionally it originates spontaneously or without the favorable action of the above-named predisposing causes. The cause of noma is an infection, but no specific bacterium seems responsible, various bacteria having been described by different investigators, such as streptothrix, spirilla growing symbiotic with Bacillus fusiformis, and the bacillus

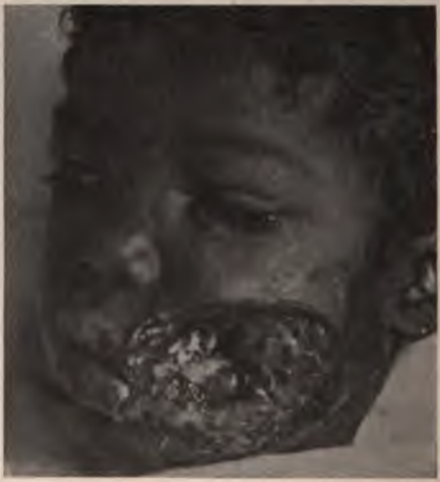

Fig. 33.—Noma, after separation of necrotic tissue. Negro child, six years of age.

of diphtheria. Cases produced by the latter have been relieved by the administration of antidiphtheric serum. It is probably more accurately attributed to mixed infection. Recent investigations indicate that the most frequent if not the sole cause is Vincent's Bacillus fusiformis.

Local Appearance.—The beginning of noma is an infiltration which appears usually in an ulcer or blister on the mucous membrane near the angle of the mouth, or, exceptionally, in other parts of the mouth. The mass can be felt as a lump in the cheek and soon becomes gangrenous. On the cutaneous surface the first change is a cyanotic discoloration, later becoming black, surrounded by a red, inflammatory border. The cheek is otherwise pale and swollen. A bleb is sometimes formed over the necrotic mass. A kind of pseudoline of demaraction may form, and the slough be cast off, leaving the characteristic perforation of the cheek. But the line of demarcation here has not its usual significance, for the gangrenous process usually spreads rapidly and spares nothing in its course. The bones of the face are laid bare and may become necrotic. The tongue usually escapes. The hideous picture of noma in severe forms can scarcely be described. The swelling of the face and neck, the destruction of tissue from mouth to ear, from ear to eye, the exposure of the naked bone in the midst of the decomposing tissues, the sight of the mouth cavity and the teeth, from which the gums and perhaps the bone have been destroyed, produces one of the most revolting pictures of pathology. It is unnecessary to add that the odor is horrible.

General Symptoms.—The constitutional symptoms are severe from the beginning. The temperature is high and continuous and the pulse rapid, small, and low of tension. A chill may occur at the beginning and may be repeated. Prostration is great, and this, combined with the elevation of temperature, is a good index to the prognosis. Mental symptoms are especially marked, delirium and coma being often present almost from the beginning and remaining until the end. When noma comes as a complication of an infectious fever, the symptoms may not be recognizable, and appear to be only an exacerbation of the predisposing disease. Aspiration-pneumonia is the most frequent cause of death.

When the vulva is attacked by noma the labia are usually attacked, and from this point the gangrene spreads until it covers the perineal region, and it may extend to the buttocks, thighs, or mons veneris. The same tendency to spare nothing, and to extend deeply and affect the bony structures, is seen here as in noma oris. If the patient recovers, the awful deformity remains to be relieved, usually only partially, by plastic work.

Carbolic Acid Gangrene.—The widely extensive favor of carbolic acid as an antiseptic, and the frequent use of the drug in the treatment of such conditions as acute abscesses, bursal ganglia, and hydrocele renders it important to call attention to carbolic acid gangrene. It is perhaps the most frequent type of gangrene produced by the local effect of chemicals. Lysol sometimes behaves in the same manner.

When carbolic acid is applied, even in weak solution, and is allowed to remain in contact with the tissues for several hours, water evaporates, and causes thereby constant and continued increase in the strength of the solution. So that if the original solution was too weak to cause gangrene, the increase by evaporation may do so. Tissues do not bear prolonged contact with the drug. The first local effect of carbolic acid is the blanching of the tissues and anesthesia. After the anesthesia is produced the patient may not be able to recognize that the tissues are being damaged. After the tissues are blanched they become black and a dry gangrene is established. This may involve only the upper layers of the skin or extend to any depth, so that a whole digit or a large mass of tissue may be lost.

Decubitus, or Bed-sore.—This is a pressure necrosis, favored by the poor vitality and the emaciated and often unconscious condition of the patient, and produced by compression of the tissues between the bed and the bony eminences of the body, such as the sacrum, the trochanters, the heel, the malleoli, the spines of the vertebræ, the spine of the scapula, and the olecranon process. A similar process is that occurring by pressure of splints, plaster casts, and other surgical appliances. The condition occurs usually in patients who are bedridden and unconscious, or who are poorly nursed, or in those whose nerve-supply to a portion of the body has been rendered functionless, as in cases of paralysis and in compression or severance of the spinal cord. In these latter cases trophic disturbances also favor the development of decubitus.

The first evidence of decubitus is a red spot at a point where pressure is known to have occurred. This spot is painful, possibly tender, if the general condition or the nerve-supply does not preclude the production of pain. So long as the skin remains red there may be a chance of preventing necrosis. Further pressure guarantees it. When necrosis occurs the spot becomes whitish or an ashen gray and loses its sensitiveness. Later it becomes brown or black, and separates as a dry slough from the living tissues. Infection is very likely to take place and often very disastrous in large bed-sores, as an inflamed, painful, foul ulcer is the consequence, and pyemia or septicemia may develop at any time, especially when the ulcers are large, multiple, or improperly attended.

Ainhum.—This is a curious and unexplained type of gangrene. It is a disease of the native negro of the west coast of Africa and occasionally in the East and West Indies. Its cause is not known; some authors have tried unsuccessfully to identify it with leprosy. It affects men more frequently than women, and usually attacks the little toe, although the fourth toe or the little finger may occasionally be attacked. It is frequently bilateral. A fissure appears on the plantar surface, near the base of the digit, gradually surrounds it and deepens as if a string were tied around it; then swelling and gangrene of the distal part occurs, and the digit drops off; healing follows, and the general condition remains undisturbed. The appearance of ainhum, under various circumstances, has led to the belief that a variety of causes may produce it by causing the development of a fibrous band around the digit.

Treatment of Gangrene.—The treatment of gangrene assumes several phases, dependent upon the type. The first phase is that of prevention. In all cases where conditions favor the development of gangrene, and in all operations the nature of which might favor necrosis of tissue, prophylactic measures must be instituted and continued until the danger is passed. Thus, ligation in continuity must be done at such points of election as will favor the most efficient collateral circulation, and the part whose blood-supply is dangerously reduced by ligation must be elevated, kept free from constricting dressings, held at or above the normal temperature, and guarded assiduously against infection; failure in any one of these details may prove disastrous, and each added offence multiplies the danger manyfold. Further than this, the prophylaxis may be briefly summed up in the statement that all predisposing and exciting causes of gangrene should be prevented or removed as much as possible, and that surgical procedures should be undertaken in susceptible individuals only when absolutely necessary.

The treatment of gangrene requires the most astute judgment. The questions usually arising are: Whether to operate or not? Whether it is better to wait for the appearance of a line of demarcation? At what level above the gangrenous limits should removal be done? Under what circumstances is it necessary to do a higher amputation?

The first question is answered in a general way in the affirmative. Gangrenous tissue must be removed from living tissue or it will come away naturally as a sphacelus. In the majority of instances it is preferable not to wait for natural separation, and in all cases where a delay could cause an increase in the quantity of gangrenous tissue, or where constitutional symptoms are marked or increasing in severity, it is best to operate. In all cases where, owing to anatomic conditions, separation of the living from the dead tissue cannot occur, operate; when the raw surface left by the sphacelus would be unduly large and difficult to heal, owing to its size or to infection, operate. Admitting that a gangrenous condition is self-limited, if it extends above the metacarpo- or metatarsophalangeal articulations, operate. In all those cases where the constitutional condition is such as to assure recurrence of gangrene in the flaps at any level, do not operate. In those cases in which, owing to the extent of the progress, the whole gangrenous process cannot be removed, one does better to temporize. In cases of multiple gangrenous foci which cannot all be removed, or which indicate that the tissues generally are on the verge of necrosis, it is useless to attempt operative treatment. In those cases where it is impossible to remove the gangrenous tissue and close the wound so as to get primary union, and where infection has not occurred, but can be prevented more certainly by non-operative than by operative methods, do not operate; by the time separation of the slough has occurred the general condition of the patient may be much better able to withstand a possible infection.

The question of waiting for a line of demarcation must be determined not only by the type of gangrene, but by the behavior of the case in hand. In all rapidly spreading cases of gangrene one must not wait for the development of a line of demarcation; that is to say, if infection is the cause of the gangrene, or if it is a secondary condition and accidental, but is causing rapid spread or producing dangerous symptoms, no delay can be justifiable. In cases where the general or local condition is found, after due delay, to be such that a line of demarcation cannot form, operate without loss of further time. Hence, in all cases of microbic gangrene, in noma, in senile gangrene, after it has extended from the toes to the dorsum of the foot, and in diabetic gangrene one loses important time by waiting, and the indication is to remove the parts at once, provided always that the vitality of the patient is equal to the extra demands imposed by the operation indicated. In all cases where the gangrene is self-limited or dry, one may usually wait a reasonable time with safety.

The distance of the operative incision from the gangrenou borders must be determined for each case. If infection is the cause the work must be done under the most rigid asepsis, lest reinfectio establish the process anew. And, on making incisions, it is imperative in these cases to note carefully the condition of the tissues fo evidences of infection, such as necrotic fascia, emphysema, o venous or arterial thrombosis, which, if found, demand a wide removal of tissue with a fresh set of instruments. In spreading traumatic gangrene one is never quite safe in estimating just at wh level an amputation can be safely done. If a line of demarcatio

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has formed, it may be simply necessary to amputate sufficiently high above the line to obtain satisfactory flaps, but, when the gangrene is due to arteriosclerosis or venous or arterial obstruction, a new feature arises, namely, that the amputation must be at a point sufficiently high to get an adequate collateral circulation. Hence, in such cases it is often necessary to amputate near the knee, above or below, for a gangrene that has reached no higher than the dorsum of the foot or the ankle. In senile gangrene, diabetic, and spreading traumatic gangrene it is usually necessary to amputate high above the upper border of the gangrenous tissue.

The method of managing a gangrenous part depends on whether infection and decomposition have or have not set in. If no infection has occurred, the tegument and the cutis should be kept unbroken by protecting them with soft dry dressings and an occasional application of some antiseptic solution, as bichlorid of mercury, alcohol, carbolic acid, or tincture of iodin. The last-named drug is the best. If infection takes place, it is impossible to prevent rapid decomposition of the necrotic tissue and the associated inconvenience and discomfort. The use of deodorants and antiseptics, however, renders the situation more tolerable. The employment of dressings saturated with a solution of potassium permanganate, carbolic acid, creolin, or lysol gives the combined deodorant and antiseptic effects. Under certain circumstances it may become necessary, even in hopeless but protracted cases, to remove the gangrenous mass and deal with the remaining ulcerated surface according to indications.

Arteriovenous anastomosis has been done a few times to prevent gangrene or to check its advance with certainly enough encouragement to be recommended in selected cases. Unfortunately, the condition of the vessels and the difficulty of employing the method except in a limited way renders this treatment worthless in a large percentage of cases.

Treatment of Noma.—Noma must be recognized early to derive benefit from surgery, and the treatment must be thorough. No consideration can be entertained for the disfigurement that will result, the whole attention being directed toward complete destruction of the necrotic tissue and of the causative infection. This is done more satisfactorily with the actual cautery. Potential cauterants may be applied in default of the former, but are less controllable and certainly less efficient. The region, both buccal and facial, must be cleansed as perfectly as possible; then the mass of dead tissue is removed with scissors or scalpel and the whole of the surface cauterized; every crevice and fissure must be entered and the contained infection destroyed, lest recurrence in the whole area take place. Here, perhaps above all other types, must attention be paid to the general hygiene, the nutrition, and stimulatio of the patient. No attempt is made to shape flaps, no effort t close the hideous rent in the face. The details of this can be looke after when, and are justifiable only when, recovery is made, th tissues completely healed, and the patient's general conditio improved.

Treatment of Decubitus.—When it is known that an individu must occupy his bed for a considerable time, and when dealing wi an unconscious, weak, or paralyzed patient, efforts should inva ably be put forth to prevent bed-sores. This is all the more nece sary if emaciation, exhaustion, and a feeble circulation add to t likelihood of their production. Such individuals should not allowed to remain long in one position, but must be turned fro side to side and from side to back at intervals of from thirty mi utes to two hours, and the parts massaged once or twice a day a rubbed with alcohol. Above all things, cleanliness must be abs lute, for failure in this respect greatly favors the occurrence of be sores. The fact that the patient occupies a soft bed may delu the nurse into believing that her attention may be curtailed, but t ordinary soft bed only adds to the difficulty of prevention witho reducing the danger. If the patient must be confined to bed t remainder of his life, as in cases where the spinal cord is crushed, is better to put him on a water- or air-bed from the start.

The same forethought must be exercised in the applicati of splints and braces, and all bony prominences must be padd abundantly with soft wadding. Afterward, complaint from t patient that a bony eminence has become painful demands early investigation of the cause of pain.

When a red spot, the first step toward decubitus, appea additional activity is necessary. All pressure must be remo from this spot, and this requires care lest the additional press at other points cause trouble, where the patient lies on a surf threatened with a bed-sore; the red spot is protected by caus the pressure to fall on the regions surrounding it by the empl ment of pads, or, preferably, of a rubber ring, moderately infla with air. A dressing should be placed over the red spot, sim of dry gauze, or it may be dressed with a dry aseptic powd such as borated talcum. It must not be allowed to remain wet filthy under any circumstances. Antiseptics may be applied, b not in sufficient strength to damage the tissues. A solution iodin, 1 to 3 per cent., in alcohol is perhaps the most satisfacto Gentle massage and rubbing with alcohol must be repeated f quently during the day. The use of ointments and poultices likely to prove harmful by maceration of the epithelium and t admission of bacteria.

When the pale spot appears the whole purpose is to prevent spreading by adopting the plan just outlined above, and to avoid infection. It is better that the slough remain *in situ* and become dry than that it should come away, causing an open ulcer, sure to become infected, thus encouraging the spread of the ulcer, the occurrence of inflammation, and increasing the demands already made on the exhausted vitality of the patient. Many individuals who suffer from bed-sores die of septicemia or pyemia. When the slough is thrown off or removed the remaining ulcer is treated according to the methods mentioned under that caption.

Necrosis of internal organs may occur, and the necrotic mass become encysted and gradual shrinkage of volume ensue, with little or no constitutional evidence of the actual pathology, except where sufficient tissue is lost to interfere perceptibly with function. If infection occurs, abscess or one of the general septic conditions will arise and must be dealt with accordingly.

CHAPTER VIII

ULCER

ULCER is a gradual loss of tissue by disintegration involving a surface.

Ulcer is distinguished from gangrene by the fact that in gangrene gross masses of tissue die, while in ulcer the mass is minute; in gangrene the dead tissue remains for a time, in ulcer it is gradually thrown off and lost. As gangrene is death of tissue *en masse*, so ulcer is death of minute quantities of tissue, "the molecular death of tissue."

The simple fact that tissues disintegrate does not constitute ulcer; these tissues must be lost or separated from the living tissue, and there must, at the same time, be a loss of surface covering, so that ulcer is possible only when appearing on a cutaneous, mucous, or serous surface. The same process occurring within the tissues or organs, but not affecting a surface, is called necrobiosis.

Etiology.—The causes of ulceration are numerous, but produce their effects in accordance with principles already sufficiently elaborated. They are predisposing and exciting.

The predisposing causes of ulcer are all factors interfering with the nutrition of the part, and are identical with the predisposing causes of inflammation and gangrene. If the predisposing causes are well established, and interfere extensively with the nutrition of the part, then the most trivial additional disturbance may initiate an ulcer, which continues to spread or persistently remains until the predisposing factor can be at least partially eliminated. Among the most frequent predisposing causes of ulceration may be mentioned syphilis, diabetes mellitus, gout, uremia, tuberculosis, general anemia, marasmus, and typhoid fever of the constitutional diseases; and of the local conditions, varicose veins, prolonged edema, trophic disturbances, as seen in diseases and injuries of the cord and large cicatrices whose blood-supply is subnormal, and malignant tumors.

The actual causes of ulceration, on the contrary, are often capable of establishing ulcers without synergic predisposing conditions. Ulcers may result from burns, wounds, contusions, prolonged pressure, frost-bite, escharotic drugs, electricity, *x*-rays, radium, and bacteria; these are identical with the exciting causes of inflammation, and here, as in inflammation, bacteria must be accepted as the chief cause, though by no means so predominantly so. In almost every ulcerative process bacteria soon or late become implanted and their action is, with an occasional exception (see Erysipelas), in line with the agents that maintain the ulcer, and often they alone are responsible for the pathologic picture. Certain drugs may cause ulceration when taken in overdoses, as seen in mercurial poisoning.

Pathology of Ulcers in General.—Certain fundamental facts must be borne in mind in the study of ulcers. There is an antagonism of forces in action, either of which may predominate. The ulcerative process is engaged in destroying tissue and extending the limits of the ulcer, and associated with this is an accidental or essential infection. On the other hand, the healing process is bending the energies of the tissues to repair the rent made. The healing process may be so active as to build up large quantities of new connective tissue around and beneath the surface of the ulcer, which, by contraction, limits the blood-supply to the ulcer, and thwarts the very purpose for which it is intended, and in turn must yield to the ulcerative process. Hence, an ulcer may present any variation between normal healthy granulations and a surface not only devoid of signs of healing, but covered with necrotic material or a pseudomembrane, and possibly spreading rapidly. The former condition is ideal; the latter represents the worst types, and there are all gradations between. There may be islands of granulations small or large, and these may come and remain a while, and then be, in their turn, destroyed.

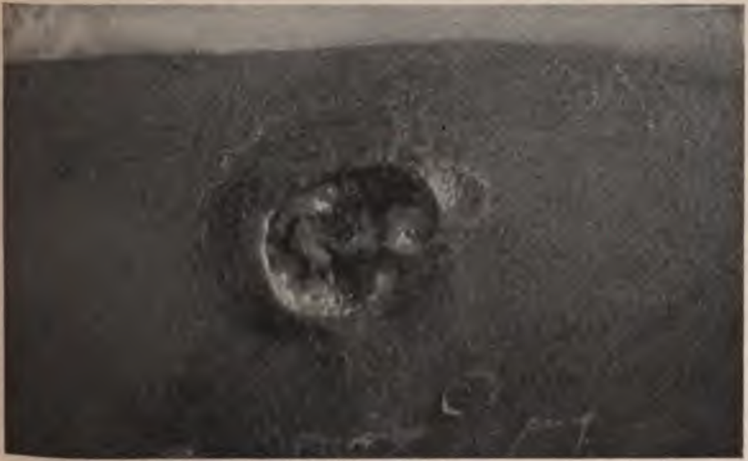

Fig. 34.—Diabetic ulcer of leg.

Shape.—The shape of ulcers is round, oval, irregular, or linear; occasionally an ulcer creeps from its original site by extending on one side while healing on the other; these are called serpigenous ulcers.

Margin.—The edges of an ulcer may be smooth and flush with the surrounding skin or elevated above its level. They may be soft or indurated, and this induration may be infiltrative, cicatricial, or malignant.

The area of the ulcer base may be equal to that of the opening in the tegument, the walls vertical. This is the punched-out ulcer. The area of the base may be smaller than the opening in the tegument, so that the edges are spoken of as sloping. The area of the base may be larger, often much larger, than that in the tegument, and this is called an undermined ulcer.

The base of an ulcer may be smooth and covered with granulations; it may be covered with necrotic material or a false membrane; it may be devoid of all the preceding and expose the anatomic structures in its base; it may be irregular or mouse eaten.

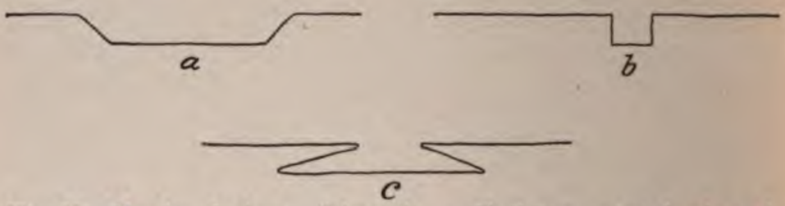

Fig. 35.—Margin of ulcers. Schematic: *a*, Sloping or everted edges; *b*, punched-out ulcer; *c*, undermined ulcer.

The discharge from the surface of an ulcer may be abundant or scanty. It may be serous, purulent, seropurulent, or sanious, according to the type of ulcer and the condition of the raw surface. In ulcers where the death of tissue is rapid, and in those cases not kept clean, the discharge is fetid and at times may be offensive. This is especially likely to occur in phagedenic, rodent, and indolent ulcers.

Classification.—The classification of ulcers may be made easier by placing them into two grand divisions, namely, non-specific, or simple, ulcers and specific ulcers. In the first group are placed all those which depend on ordinary non-specific causes or the ordinary pyogenic bacteria, and those cases arising from constitutional conditions which are not of parasitic origin; and, in the second, all those produced by specific infection, whether it acts locally or is simply a local manifestation of a general infection; ulcers dependent upon malignant processes are placed in this group. However, as any ulcer, of whatever origin, will, from a surgical standpoint, conform to one of a few types, it is deemed better to study them in the light of these types rather than to enter into the endless details imposed by studying them from the standpoint of etiology.

Granulating, Healthy, or Healing Ulcer.—Much discussion has been wasted for and against placing this condition in the category of ulcers. Admitting that good arguments are made by both sides, it remains a fact that surgeons continue to speak of healthy or healing ulcer, in spite of the glaring contradictions between the terms "healthy" and "healing" and the definition of ulcer. Yet, if we can understand definitely what is meant by the term no harm can come; on the other hand, it would be equally contradictory to omit it, for then an ulcer would cease to be an ulcer when it began to heal.

A granulating ulcer is an ulcer healing normally, and cannot be distinguished from a wound healing by second intention; pathologically they are identical. It is the ideal state to which it is the hope of the surgeon to bring every ulcer which he undertakes to cure as an open sore.

The granulating tissue of a healthy ulcer is firm and pink, and the surface is covered with small granular-shaped bodies of new tissue. There may be a serous or seropurulent discharge from the surface, but the quantity is not great. The margin of the ulcer is encircled by a bluish-white line of new-formed epithelium, extending from the skin on to the surface of the granulations, which grows on the average of 2 to 3 mm. per week. There will be little variation of the surrounding tissue from normal.

Treatment.—No treatment is necessary beyond the application of clean dressings as the case may demand, cleansing the surface and surrounding skin at each dressing preferably with dry soft sponges made of gauze, or by employment of normal salt solution. If for any reason medicaments must be applied, one must make sure they are mild and harmless to granulation tissue. A little calomel or boric acid may be used, but one can hope to gain little advantage by meddling with normal healing. The repeated application of bichlorid of mercury solutions is positively harmful, and even water or saline solution is of very questionable practice.

Fungous, Exuberant, or Hypertrophic Ulcer.—This type of ulcer is characterized by an excess of granulation tissue which is unhealthy. The mass of granulations may extend above the level of the surrounding integument, and is soft, flabby, at times semigelatinous, pale, and easily broken down. The skin edges show little or no tendency to cover the granulations with epithelium, and the size of the ulcer remains the same or becomes larger, while the mass of exuberant tissue continues to grow. The excessive granulations are spoken of by the laity as "proud flesh."

Exuberant ulcer occurs more readily in the anemic, the tubercular, in alcoholics, and those whose hygienic surroundings are bad. The great dread of this form of ulcer entertained by the laity has no reasonable foundation.

Treatment.—The first desideratum in exuberant ulcer is to correct the predisposing condition, and to administer tonics, stimulants, improve the surroundings, and correct the diet.

The local treatment consists in the removal of all unhealthy granulations by the knife, curet, or cautery, and the employment of Bier's hyperemic treatment once or twice daily. In the beginning, when these ulcers first show evidence of their true nature, the topical application of a strong solution of silver nitrate or carbolic acid will often correct the condition. After removal of the hypertrophic tissue, the surface may be painted with iodin or dusted with iodoform at every dressing or at alternate dressings. A sharp outlook must be kept for reappearance of unhealthy granulations and action taken accordingly.

Chronic, Callous, or Indolent Ulcer.—There are many varieties of chronic ulcer which must be discussed somewhat in detail. All chronic ulcers are necessarily indolent, but they can be described as callous only when a considerable amount of cicatricial tissue has formed in the base and around the edges of the ulcer, giving it a hard feel, and making it more or less immovable by the dense attachment of this new-formed tissue to the underlying structures.

The most frequent type of chronic ulcer is the varicose ulcer and certain of the specific ulcers, particularly the tertiary syphilitic. When both factors are active the ulcers are rendered much more stubborn. The beginning of chronic ulcer is usually accreditable to an injury, which may be very slight, such as a scratch or a slight bruise in a region rendered favorable on account of varicose veins, However, the ulcer may begin without such injury. It is found usually on the leg or foot, and is associated with trophic disturbances or varicose veins, or comes as a sequel to venous thrombosis following a general infection like typhoid fever. In syphilitics this ulcer may appear as a tertiary lesion at various points on the body, but even in these it is seen more often on the leg.

Chronic ulcer may be very small, and reach only through the skin, or it may be so extensive that practically the whole surface of the leg from knee to ankle is affected, and may extend in depth until muscles, periosteum, and bone are attacked. This ulcer is seen more frequently in the old, although it may be seen occasionally in young individuals. The ulcer starts out from the beginning as a chronic lesion, and may continue indefinitely, thirty or forty years, either maintaining a fairly uniform size or gradually extending in diameter and depth from the starting-point. Syphilitic ulcers are more likely to extend in breadth and depth than non-syphilitic. Small patches of granulations spring up occasionally and disappear without having withstood the ulcerative process long. The surface is covered with necrotic tissue and discharges a serous or seropurulent fluid, which may be at times hemorrhagic. The surrounding tissues are usually swollen, indurated, or edematous, and inflammation of the tissues may recur from time to time. The surrounding tissues often develop an intolerable, intractable eczema which annoys the patient far more than the ulcer does. Pigmented areas often surround the edges of the ulcer, and may be seen scattered about over the affected leg. They are due to deposits of hemoglobin from stagnant blood, or to scars from similar ulcers which have healed. The ulcers are usually not painful, but may be extremely sensitive, and show the characteristics of irritable ulcer. Unless kept clean these ulcers are very foul and offensive.

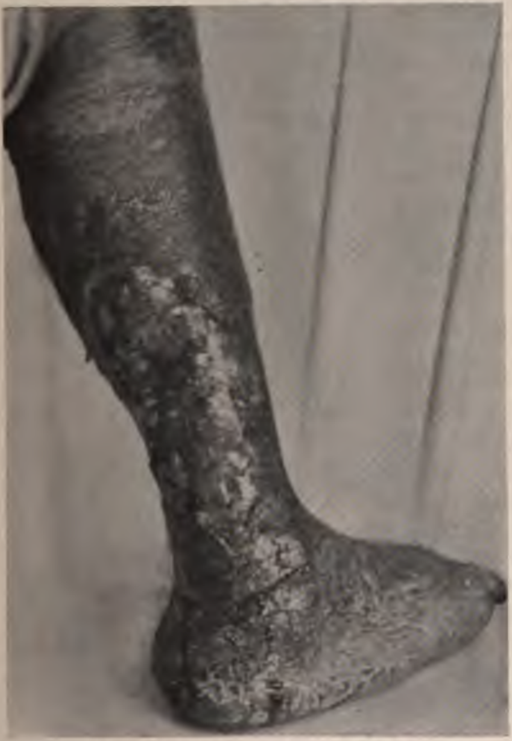

Fig. 36.—Indolent ulcer of the leg.

Prognosis.—The prognosis of chronic ulcer is poor. The ulcer can be cured usually if the patient will submit to the necessary restraint, and this he is often loath to do. However, after healing is complete, the return to normal practices is very frequently followed by recurrence. In the larger ulcers loss of limb is frequently the only hope of relief.

Treatment.—The first condition of successful treatment of chronic ulcer is absolute control of the patient. More failures are perhaps attributable to this fact than can be found in any other curable condition. Without such co-operation success is precluded in all severe cases and improbable in many of the milder ones. The first step of treatment, therefore, is to rest and elevate the part. The rest must be absolute and the elevation sufficient to prevent venous stasis. If syphilis is a possible factor, antisyphilitic treatment must be directed *pro re nata.*

Second. The ulcer must be kept clean and the accumulation of dead epithelium and dried secretions around the edges must be removed occasionally, and uniform pressure made over the ulcer and the adjacent region by the application of elastic dressings or stockings. Unna's paste or adhesive strips imbricated and allowing a small vent for the discharge accomplish this end admirably. The frequency of these dressings depends on the individual case.

Third. If the ulcer is old and calloused the cicatricial tissue should be removed at the beginning, preferably by incising the healthy tissue around the border and dissection of the whole ulcer base in one block, followed by ordinary after-treatment of the wound; or the base of the ulcer may be incised and scraped away with a sharp curet. Cauterization of the ulcer with the actual cautery accomplishes the same end. If bone is found diseased, but insufficiently so to demand amputation, the necrosed portion must be removed. Whether operative treatment has been necessary or not, it is very beneficial to use Bier's hyperemic treatment or Wright's solution, which contains citric acid, ½ of 1 per cent.; sugar, 10 per cent.; water, q. s. ad 100 per cent., which is to be kept constantly applied to the ulcer by saturating the dressings several times a day. This may be used conjointly with Bier's hyperemia.

After granulation has advanced sufficiently it is always better to skin-graft large ulcers. If varicose veins are present they may be dealt with either by palliative treatment, such as the employment of elastic stockings, or by radical operation. The patient should not be permitted to return to his usual vocation without such care of his varices, and should be instructed to return for treatment on the first evidence of recurrence of the ulcer.

If it is absolutely necessary to treat a chronic ulcer and allow the patient to continue on foot, there is no question but that uniform pressure, as accomplished best by application of Unna's paste, is the most satisfactory method of treatment.

Painful, Irritable, Erethistic, or Congested Ulcer.—This ulcer is characterized by its chronicity and by its painfulness and sensitiveness. It is painful on account of exposure of a nerve from destruction of the nerve-sheath. This point can be located by touching the surface of the ulcer with a small probe; the remainder of the ulcer surface is usually not sensitive. The sensitiveness is so great that dressings are intolerable, and even exposure to the atmosphere causes pain.

Painful ulcers are seen more frequently in women who have menstrual disorders, and as a complication of varicose veins and in the anus, usually at the posterior commissure, where they are called fissures, and in the lips. When they appear on the leg, their favorite site is over or near the internal malleolus; at this point the first evidence is the appearance of a red spot, which gradually becomes cyanotic, and breaks down spontaneously or following slight trauma, and then gradual enlargement follows, with thickening of the connective tissue and induration of the base and edges of the ulcer and attachment of its base to underlying structures. Epidermization and granulations do not appear, and there is not only great difficulty in relieving the suffering and healing the ulcer, but considerable probability of its recurrence. Aside from the subjective symptoms and the location, it is impossible to distinguish this ulcer from an indolent ulcer.

Fissure in ano results from the passage of hard fecal masses, and, therefore, is traumatic, and is predisposed to by all diseased conditions which reduce the vitality of the anal lining and those favoring constipation. The ulcer is longitudinal, and may be situated at any point on the circumference of the anus, but usually at the posterior commissure. At the lower end of the linear vertical fissure there is often found a mass of thickened tissue, resembling somewhat an external hemorrhoid, and called a sentinel pile. Occasionally this ulcer is irregular in shape. It is painful to the limit of tolerance after the passage of motions or flatus, and causes constant dread and postponement of defecation. Caused by trauma, it is maintained by it. These ulcers are often minute and escape observation, the symptoms being attributed to lesions of some anatomically correlated structure. They are not indurated.

Fissures of the lip rarely partake of the nature of chronic ulcer.

Treatment.—Hilton recommended location and excision of the painful spot with a small amount of surrounding tissue. If the whole surface is sensitive, complete dissection or crucial incisions are recommended. The pain may be controlled by local applications of cocain and kindred drugs, opium, chloral, and similar anodynes, in the form of an ointment.

Fissures may always be relieved by incision and cauterization or curettage of the ulcer surface. But it is preferable to excise tl fissure and suture, or to make an incision through the long axis (the ulcer, well down into the substance of the sphincter muscl sufficiently deep to put that portion of the muscle influencing th ulcer at rest. The general condition must be built up and th habits regulated to obtain or maintain a cure.

Malum Perforans Pedis, or Neuroparalytic Ulcer.—This ulcer as its name would indicate, occurs on the foot, is chronic, an is usually associated with some disturbance of the nerve-supply t the part.

The causative conditions most frequently held responsib for the lesion are locomotor ataxia, syringomyelia, paretic dementi spina bifida, traumatisms, and inflammation of the nerves, the centers, or the encasing bony tissue, diabetic neuritis, 'tumors (the nervous system and arteritis, syphilitic or alcoholic, and va cular sclerosis. The causative factors, in brief, are reduced sens bility and sclerosis. It is sometimes seen in anesthetic lepros The condition depends upon continued pressure for its excitir cause.

Malum perforans occurs on the foot at one of the three weigh bearing areas of the sole, namely, the heel, the head of the fift metatarsal, or the head of the first metatarsal bone; in the majorit of cases it occurs at the last-named spot. It is usually found adults well advanced in years, but has been seen in children. Tl first evidence is usually a callous spot on the sole of the foot, b now and then it begins in a wound or a new-formed bursa. Tl onset is announced by a localized inflammation which may supp rate, and is followed by necrosis of the tissue. The slough fa away and an ulcer forms, deep, circular, with distinct edges, whi are hard and abrupt or undermined. The ulcer may remain *statu quo*, or, especially if pressure is continued, may slowly exte more deeply, and involve bone or joint in its necrosis. Granul tions are not present, and a thin, watery, or purulent discharge poured out. The ulcer is painless and the surrounding tissues a anesthetic or analgesic. Trophic disturbances of the integume and nails, especially hypertrophy, are often associated with malu perforans. The ulcer may eventually heal, and without know provocation recur, and this healing and recurrence may alterna with each other for years. The ulcer is usually resistant to trea ment.

Treatment.—First, all pressure should be removed and the fo placed at rest. This point needs to be insisted upon, because in tl painless condition the patient cannot tell when he is doing injur The ulcer must be cleansed or dissected out or the free overhangi edges cut away and the cavity thoroughly curetted. Heat may l applied by immersion in hot water for half an hour or more twice a day. Bier's treatment and the stimulating and mildly antiseptic drugs, such as iodoform or balsam of Peru, may be applied. Neurectasy of the main nerve-supply of the part is recommended as highly efficient.

In any case, the predisposing cause must be sought and as far as possible corrected. Recurrence is frequent, and instructions should be given to avoid unnecessary pressure on the dangerous points and to inspect the foot frequently for signs of return.

Phagedenic Ulcer, Spreading Ulcer.—Phagedenic ulcer is caused by infection in most cases; a similar condition appears occasionally as the result of cachectic conditions associated with protracted exhaustive diseases, but the real cause here is infection, which flourishes more rapidly because of diminished tissue resistance. The most frequent phagedenic ulcer is the chancroid, or soft chancre, which is transmissible, usually by sexual contact. Phagedenic ulcer may start *de novo* as such, or it may become engrafted upon some other type of ulcer or on a wound. The constitutional condition seems to play little part in chancroidal ulcers. An abrasion is necessary for the admission of infection, but the abrasion may be very minute. Within a very few days, at times within twenty-four hours from the date of infection, a small inflammatory nodule appears and soon becomes a pustule; if the atrium is sufficiently large, no pustule forms. The pustule ruptures and a well-defined ulcer results, which continues to discharge pus and to enlarge, while, at the same time, it extends in depth. The ulcer is very frequently undermined and often forms a tube-like subcutaneous channel. Hence the superficial evidence is misleading as to the true condition, and, unless thorough examination is made, the undermined portion will escape untreated. These ulcers may spread slowly or rapidly; when they spread rapidly they frequently show necrotic pieces of tissue of considerable size and destroy considerable volumes of tissue. The glans penis is often considerably disfigured by them, but is rarely completely destroyed. They produce glandular involvement and the glands often suppurate. This pus may be sterile or may contain innocuous bacteria, or it may contain numerous virulent micro-organisms, a fact that explains the difference in behavior of the wounds when excision of the lymph-nodes is contemplated. In the former two conditions the wound behaves kindly and heals rapidly, while in the latter a new ulcer is established, control of which may not be gained until it has grown several inches in diameter. Hence, incision is better here. The pus from the primary sore is always infectious. The primary sore and the chancroidal bubo are nearly always more or less painful and sensitive, and this is used as a differential point between the soft chancre and true or hard chancre. The latter does not spread extensively as soft chancre does, does not suppurate, and does not produce extensive or marked glandular enlargement, and the gland or glands which do enlarge are painless and non-suppurative. Mixed infection is frequent, and it is then impossible to say whether syphilitic infection is present or absent, except by the discovery of Spirocheta pallida, the appearance of secondary symptoms, or a positive Wassermann reaction, as the activity of the chancroidal infection obscures all characteristics of the syphilitic primary sore.

Operations for such conditions as varicocele, hydrocele, circumcision, and especially hernia must not be undertaken during the existence of phagedenic ulcers, for it is well-nigh impossible to avoid infection at the time of operation or subsequently.

Phagedenic ulcers are occasionally so rapid in their spread as to deserve the title of gangrenous ulcer. In these ulcers anaërobes are recoverable, and are probably the cause of most, if not all, such cases, a fact which closely allies them to the lesions produced by the Bacillus aërogenes capsulatus.

Phagedenic ulcers are often multiple, and are almost certain to occur in folds of the skin or mucous membrane which covers the ulcer. They may coalesce and form an ulcer covering the whole region formerly occupied by numerous ulcers.

Prognosis.—The prognosis of phagedenic ulcer is good except where the general condition of the patient is so wretched that healing cannot take place. Frequently they continue to spread for five or six weeks, the destructive stage, and then without treatment the surface cleans off, the dead tissue comes away, and the denuded base assumes the characteristics of healing ulcer, the stage of repair.

Treatment.—The prevention of phagedenic ulcer is the same as that of any other virulent infection. No wounds are to be made in the infected region except under direst necessity, and if they become necessary they should be sealed up with collodion or otherwise until healing is complete.

When phagedena is recognized, the first step necessary is that the whole region surrounding the sore be rendered aseptic. The necrotic surface should be cleansed and all products removed, all sinuses recognized and slit up. Then, under general or local anesthesia, the whole ulcer surface must be thoroughly cauterized as well as all raw surfaces made by incision. If any part of the infection is left undestroyed recurrence is certain. Delay to use the cautery, actual or potential (nitric acid is the favorite), means usually a greater sacrifice of tissue than cauterization would make. Every care is needed to prevent reinfection. I have seen it produced by contact of the almost healed ulcers with infected clothing which a slovenly patient had refused to change. After cauterization it is best to tell the patient that the sore will be larger for a few days owing to separation of the eschar. After cauterization, dress with an aseptic dressing until granulations appear and the eschar is thrown off. Then the treatment should be the same as that of healing ulcer. It is often advisable to apply a wet dressing, and an aqueous solution of nitric acid 1 : 500 is perhaps the most satisfactory. On the other hand, some phagedenic ulcers refuse to heal under wet dressing, and must be dressed with a dusting-powder, with balsam of Peru, or with a simple dry dressing.

Rodent or Eating Ulcer.—This ulcer is an ulcerative epithelioma. The tumor appears especially on the exposed surfaces of the body, usually on the cheek, lower lip, nose, ear, eyelids, and brow, and far less frequently on the hands. This tumor ulcerates as it grows, and a shallow, irregular, or round sore forms, showing no granulations, for the most part dry or discharging a little serous or bloody fluid, and surrounded by a border which is narrow and usually very little raised. Occasionally the surrounding border is nodular. The ulcer surface may be seen at times raised above the level of surrounding epithelium and even overhanging it, constituting the so-called elevated ulcer. It is entirely unlike exuberant ulcer. These ulcers are indolent and persistent, and will not respond to the ordinary treatment of ulcers. They sometimes heal at one point, but show their true nature by continuing to spread at another. They are usually painless, but by no means constantly so. When a large amount of connective tissue forms in the base, the surrounding tegument is drawn into creases and folds radiating from the edges of the ulcer.

Treatment is given under Epithelioma.

Marjolin's Ulcer.—Marjolin's ulcer is an ulcer resulting from the breaking down of an old scar, and is usually epitheliomatous in character. If it is not epitheliomatous it resembles indolent ulcer, and must be treated as such. No time should be lost, however, in determining just whether it is malignant or not. In case microscopic examination fails to prove malignancy, the treatment should be directed along the lines given under Indolent Ulcer.

In ulceration of any type the anatomically connected lymph-nodes may be found enlarged as a consequence of infection. In specific primary ulcers it is the rule to find such lymphatic involvement, which usually gives no further concern after relief from the ulcer, but occasionally they demand further attention, especially if the cause be tubercle bacilli.

Ulcers of the Mucous Membrane.—Aside from the fundamental classes of ulcer, as given above, others are found affecting the mucous membrane and occasionally the serous membranes, although these latter are usually more of pathologic interest, or, if of surgical importance, their rôle is a minor one compared with the more serious lesions of which they represent an important incident. Ulcers of the articular surfaces are thus only a manifestation of articular inflammation or infection, and those of the larger blood-vessels represent simply a phase in the advance of atheroma or arteriosclerosis. Ulcers of the mucous membrane are of sufficient importance to demand consideration. They are usually seen in the mouth, upper air-passages, larynx, bladder, vagina, small intestine, stomach, colon, or rectum. Ulcers may be produced on any mucous surface by continued pressure or erasion, as is seen in cases where stones have remained for a long period in the bladder, gall-bladder, or pelvis of the kidney. With the exception of the stomach, upper duodenum, and the rectum the majority of ulcers of the mucous membrane are due to such erasion, specific infections, or malignancy. But in the stomach, and that portion of the duodenum closely allied to it in function as well as position, and in the rectum and colon ulceration appears independent of these influences. When an ulcer appears in any hollow viscus the symptoms may be obscure or entirely wanting, and its presence be detected only by the accidental discovery of blood in the discharges from the particular viscus. On the other hand, the symptoms may be moderate or even severe, without being characteristic, and only by direct inspection with endoscopic instruments or by exploration be accurately diagnosed. Escape of blood from a hollow viscus, even when abundant, cannot be taken as positive proof that ulcer exists, especially when the blood appears without a corroborative symptomatology or history. So, in certain conditions, an essential hematuria may occur or hematuria complicating a general disease, such as malaria, without the presence of lesions in the mucous membrane of the genito-urinary tract, and melena with no discoverable ulcer of the alimentary tract is seen at times in obstruction to the portal circulation. An ulcer situated in any hollow viscus may gradually extend in depth until it perforates or so weakens the wall that it cannot withstand the necessary intravisceral pressure. The outcome in such cases depends on the space into which the rupture occurs, and on the presence or absence of adhesions on the serous surface, which, if sufficient, may prevent escape of visceral contents or limit them to a restricted field and render the accident comparatively harmless.

Gastric and Duodenal Ulcer.—Simple ulcer of the stomach, known also as round ulcer of the stomach, chronic ulcer of the stomach, or *ulcus ex digestione*, occurs with great frequency (ulcer of the stomach was found in 4.4 per cent. of 59,000 autopsies), and depends for its etiology upon the digestive action of stomach secretions upon the mucous, muscular, and peritoneal layers of the gastric wall after their vitality has been reduced by vascular disease, as arteriosclerosis, necrosis, hyaline degeneration, and fatty degeneration of the intima, by thrombosis, hemorrhage from passive congestion, or infarction. Gastric ulcer also appears in cases of chlorosis, in which the alkaline element of the blood is subnormal and in patients who have received severe burns, regardless of the part of the body affected. There can be no doubt that traumatism and the ingestion of substances which, by their heat or their chemic action, impair the vitality of the mucosa serve as causes favoring the destructive action of the digestive fluids. The exact value of infection as a cause has not been satisfactorily determined, but it seems certain that many gastric ulcers occur without the assistance of bacteria, for the stomach has the power of autosterilization, and the frequent excess of HCl in ulcer cases favors this function.

The sites of predilection are the small curvature, the posterior wall, and the pyloric end; however, they may occur on any surface which comes in contact with gastric juice. Gastric ulcers vary in size, from a diameter of $\frac{1}{8}$ to 3 or 4 inches, and in depth from a superficial destruction of the mucosa to complete destruction of all the coats of the stomach wall. The surface of the ulcer varies with its age. At the beginning it is brown or dirty brown, and later becomes clean and smooth, showing the structures of the stomach coats. The ulcers are, if deep, terraced or funnel-shaped and are larger at the mucosa. If the ulcer is recent the tissues surrounding it are soft, but when chronic, the base and edges are infiltrated, and may show an abundance of cicatricial tissue, which draws the surrounding wall into various abnormal shapes; in this way the hour-glass stomach is produced. The ulcer is usually round or oval. There may be several and coalescence occurs occasionally. The ulcer may be situated at the pylorus, one wing lying in the stomach the other in the duodenum (saddle ulcer).

The presence of gastric ulcer may cause no symptoms and be recognized only postmortem, or when an accident, like perforation or hemorrhage, takes place. On the other hand, it may produce typic symptoms of pain after eating, when gastric acidity is highest, amelioration by additional food, vomiting, tenderness, and hemorrhage, often occult, in the stomach contents or stools. The presence of excessive hydrochloric acid often accompanies ulcer; likewise it often appears in the absence of ulcer; and the total acidity may be subnormal in the presence of ulcer. It is an unreliable sign. Blood in the stomach contents is perhaps the most important clinical finding. In all cases of gastric ulcer albumin should be found in the stomach contents; use lavage at evening;

allow no food over night; recover the stomach contents the following morning before food or drink is taken; albumin should be present. Examination of the stools for blood should be done only after elimination of ingested blood and hemoglobin; purge with castor oil; afterward give no food which could contain blood or hemoglobin even in minute quantities; examine stools at the end of twenty-four hours. If blood is discovered, it is certain to have come from the alimentary tract.

Acute Ulcer.—Acute gastric ulcers are much less frequent than chronic. They are usually small. They may develop rapidly and even cause perforation within a few days.

Complications and Sequelæ.—The complications and sequelæ of gastric ulcer are grave. Pyloric obstruction, hour-glass stomach, adhesions, perforation, and perigastric abscess are the most important. Cancer of the stomach frequently, if, indeed, not in the vast majority of cases, originates either in an ulcer or in the cicatrix left by healing of an ulcer.

Duodenal Ulcer.—This ulcer is closely allied to gastric ulcer; it is similar in type and in etiology. It is always situated in the upper part of the duodenum, that part being closest of kin to the stomach, and is rarely seen more than 1½ or 2 inches below the pylorus. It is more frequent in men. It is oftenest seen in adults, but has been observed in the newborn. Its symptomatology is not so clear and definite as that of gastric ulcer. There is usually a history of recurrent attacks. Pain and discomfort after eating, long enough afterward for digestion to be well under way, and hunger pain, relieved by taking of food (these patients frequently take a biscuit to bed with them), tenderness, and blood in the stools are the diagnostic symptoms. Examination of gastric contents is of little value. Duodenal is much less frequent than gastric ulcer, and far less likely to be followed by carcinoma. Often the first evidence of duodenal ulcer (in half the cases, according to Wanach) is perforative peritonitis. Perforation occurs much more often on the anterior than on the posterior surface.

Treatment of Gastric and Duodenal Ulcers.—The treatment of gastric and duodenal ulcers may be subdivided into the treatment of the ulcer as such and of the complications. The treatment of ulcer is either medicinal or surgical. It must be understood that the ulcers cannot be dealt with as those that can be treated under direct vision and have topical remedies applied.

Medical or non-operative treatment is carried out by a strict regimen of diet of fluid or semifluid character, rest in bed, neutralization of acid secretions, if they are present in sufficient quantities to demand it, withholding the food substances from which hydrochloric acid is derived, particularly sodium chlorid, and the administration of such drugs as by experience have shown themselves most efficacious. Of these drugs, nitrate of silver and bismuth subnitrate head the list. Gastric lavage is of questionable value and is capable of positive harm. Such a regimen may be followed faithfully for six or eight weeks, and, if marked improvement or cure does not result, surgical treatment should be done. If, after apparent cure, recurrence takes place the case becomes surgical.

All cases of recurrent ulcer, all cases not responding to internal treatment as outlined above, all cases showing evidence of such complications as abundant hemorrhage, protracted or frequently repeated, so that emaciation and anemia result, all cases showing suspicion of malignant change, all cases producing obstructive symptoms or evidence of hour-glass contraction, adhesions, or perforation admit of no question—they are surgical cases.

The surgical treatment of gastric and duodenal ulcer may deal directly with the ulcer by excision, if its size and location admit, and this is the ideal treatment. If this cannot be done with safety, the second best treatment is drainage of the stomach and shutting the food from its normal course, so that it comes as little as possible, or not at all, into contact with the ulcer surface. This is accomplished by gastrojejunostomy or an equivalent, with such additional measures as will guarantee that the artificial opening shall remain patent, and that the food shall continue to pass through it rather than *per viam naturalem*. Furthermore, it is wise, where possible, to infold the ulcer from the peritoneal surface, a protection against postoperative perforation or hemorrhage and a guarantee of early healing.

In a few cases of gastro-enterostomy recurrence of the ulcer takes place at the new opening or in the small intestine, which is directly exposed to the acidulated, peptonizing contents of the stomach.

Ulcers of Anus, Rectum, and Sigmoid Colon.—Ulcers are very frequent in the terminal portion of the alimentary tract and are of many varieties.

Etiology.—The etiology of ulcers of the terminal segments of the alimentary tract is identical in nature with the causes of ulceration elsewhere. Trauma, imperfect circulation, infection, and constitutional depravity are the underlying factors which result in ulceration. This portion of the alimentary tract is constantly subjected to anatomic, physiologic, and accidental conditions which favor the development of ulcers, and in consequence ulcers are found here perhaps with greater frequency than in any other equal areas of the body.

Ulcers of the anus are either simple or specific, and their presence is suggested by pain or defecation, purulent discharge, and frequently by dysuria. They are difficult to relieve, owing to the necessary function and the continual infection. Syphilis and tuberculosis must always be eliminated.

Treatment.—The treatment of these ulcers is rest, divulsion, or incision of the sphincter, maintenance of soft or semiliquid stools, cleanliness and the application of stimulating dressing, such as ichthyol or balsam of Peru, diluted with 3 parts of castor oil, and the application of silver nitrate or carbolic acid from time to time. If the two last drugs are used full strength their application should not be frequent. In case of failure by the above course, excision and immediate suture should be done, or an incision should be made partially or entirely through the external sphincter ani and healing from the bottom of the incision encouraged.

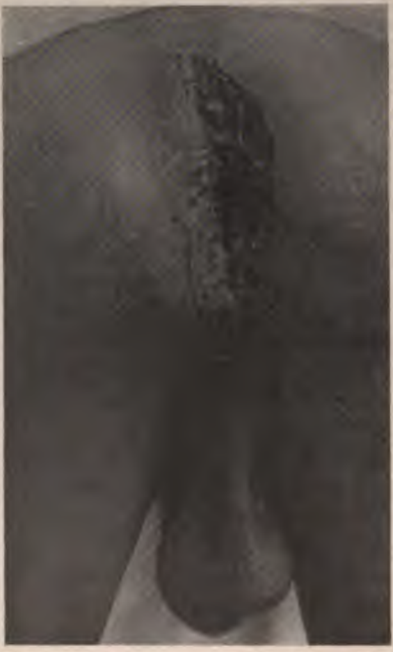

Fig. 37.—Enormous tubercular ulcer surrounding the anus.

Ulcers of the rectum and sigmoid are simple, specific, or secondary to constitutional disorders.

The simple ulcers are due to trauma, to venous stagnation, as in varicose veins, hemorrhoids or portal obstruction, or inflammatory conditions such as result from follicular or catarrhal proctitis and from strictures. In the latter condition the ulcer, of course, may depend on the cause of the stricture, result from disintegration of the fibrous tissue or from an inflammatory condition, for which in its turn the stricture is responsible.

The specific ulcers are syphilitic (rarely chancroidal or gonorrheal), tubercular, diphtheric, or dysenteric (amebic or bacillary), and occasionally typhoidal. The recognition of these ulcers, aside from any characteristic appearance, may be determined by the discovery of the causative micro-organism, or by their association with other evidences of the causative infection.

The constitutional conditions favoring ulceration of the rectum and sigmoid are diabetes mellitus, nephritis, general debility, and malnutrition.

Malignant tumors of these parts frequently degenerate, ulcerate, and bleed as in other parts of the body.

The Symptoms of Rectal and Sigmoidal Ulcers.—The motions are abnormal. They contain pus or blood or mucus, or an admixture of these; diarrhea is present and persists; it is worse during waking hours, when the patient is up; there are frequently no motions over night, but first thing on arising there is a call to stool, the so-called morning diarrhea, and the motion is not natural in appearance. If the ulcers are not situated close to the sphincter there will, as a rule, be little or no discomfort beyond a heaviness or dull ache in the lower part of the back, but when located at the internal sphincter ulceration causes marked local and reflex symptoms, and even remote symptoms may be attributable directly to this cause; these patients are nervous and irritable. Ulcers in the lower end of the rectum and in the anus often produce symptoms referable to the genito-urinary apparatus.

Treatment.—The treatment of ulcers of the rectum and sigmoid depends on the underlying condition. If this condition is removable the ulcers may be cured. If the causative condition cannot be removed the ulcers are more difficult to remove and the cure more uncertain in its permanence. In such hopeless conditions as advanced diabetes and nephritis cure is often impossible, but in the milder cases there is more hope.

The first step is removal of the cause or its correction as far as possible. Second, correction of the diet and the withdrawal of all foods that may irritate the ulcerated area. Highly seasoned foods are contra-indicated. The ulcers themselves may be treated by direct application through the speculum or by injections. Weak solutions of nitrate of silver, iodoform (5 to 10 per cent.) in olive oil, and 20 per cent. aqueous fluidextract of krameria in water are among the most useful. In ulceration caused by amebic dysentery many drugs are favorites with different authors. Solutions of quinin, cold water, antiseptics, as formaldehyd, 1 : 6000 to 1 : 10,000, and sulphocarbolate of copper, 1 : 5000, are the most important. These often fail to cure, and appendicostomy is done to facilitate colonic irrigation and bring the solutions into direct contact with the ulcers. Emetin hypodermically has recently been proved curative in nearly all cases.

In all cases of ulceration the mucous membrane of the intestines should be cleansed by enema before administration of treatment.

CHAPTER IX

SINUS AND FISTULA

Sinus.—Sinus is an abnormal opening leading from a tegumentary surface into the tissues, and is blind at its deep ending. It may lead from any surface, but it never leads from one surface to another.

Fistula.—Fistula is an abnormal opening leading from one tegumentary surface through the tissues to another. It is open at each end, and forms a communication between the two surfaces, and allows the contents found on these surfaces to pass through the opening onto the other surface. Fistula may connect a cutaneous with a mucous surface, as is seen in fecal fistula, in which the canal leads from the gut through the abdominal wall to the skin, or it may connect two mucous surfaces, as is illustrated by communication between the rectum and the urinary bladder.

The only exception to the above definition is found in *fistula in ano.* Both sinuses and fistulæ pass here under the name of fistula. A sinus leading from the skin upward toward the mucous membrane of the gut, but not perforating it, is called blind external fistula, and one leading from the anal or lower rectal lining out into the surrounding tissue, but not through the skin, is called blind internal fistula.

Etiology.—In every case of fistula and sinus there must be an establishing or creative cause and a maintaining cause. Sinus is caused either by a wound or by the discharge of pathologic contents which have accumulated in the tissues, causing an opening, such as happens when an abscess ruptures. It is maintained by the continued discharge from a persistent focus situated at its inner extremity. This focus may be a buried suture or ligature (usually non-absorbable, otherwise the sinus will not persist long), a mass of necrotic or carious bone, or some specific infection, usually tuberculous.

If the discharge is small in quantity or variable the sinus may close from time to time, and reaccumulation causes reopening of the abnormal canal.

Congenital sinuses are those resulting from failure to close of certain ducts and clefts belonging to fetal life. The foramen cecum of the dorsal surface of the tongue is a constant example of this, and another, of not infrequent occurrence, is situated in the median line just posterior to the anal outlet, and leads upward and backward over the dorsal surface of the coccyx. These are lined with epithelium and need not concern us further here (see Inclusion Cysts).

Fistulæ are established by the production of a communication between two surfaces. The cause may be traumatic, as in cases where the bladder is punctured through the rectum, or where an impacted fetal head causes necrosis of the tissues separating the cavity of the bladder from the vagina, by pathologic conditions, as seen in adhesion between the serous surfaces of two hollow organs, and the extension of an ulcer or a rupture from one into the other; or by the rupture of an abscess in two directions, or by operative means where, by accident or purposely, such a communication is made. The maintaining cause of fistula is the passage of normal secretions and excretions through the canal, or the presence of conditions, such as tubercular infection in the walls of the canal, or the presence of foreign material along the course of the fistula, and the discharge of pus and serum through two openings. The last-named condition is the equivalent of two sinuses leading to the same point and communicating with each other, one from one tegumentary surface, the other from another. Fistulæ may be main-

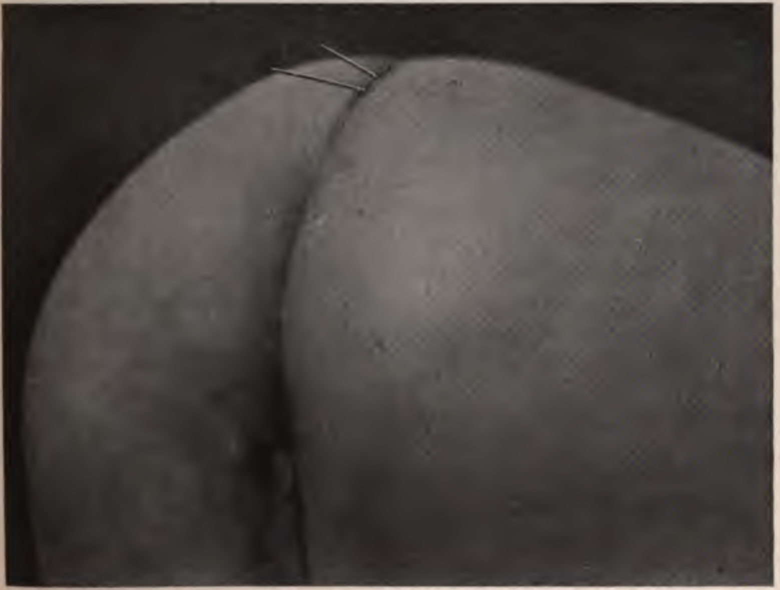

Fig. 38.—Congenital sinus over coccyx (*vide* Inclusion Cysts).

tained by the lumen of the canal becoming lined with epithelium which extends from each surface. The fistula has healed open and, instead of the raw ulcerous surface, there is normal new-formed epithelial covering. Such fistulæ are permanent—*i. e.*, they would not heal even if the contents were no longer permitted to pass through. This is the type of fistula artificially created in such operations as gastro-enterostomy and cholecystenterostomy. The closer the two surfaces connected by the fistula are to each other, the more probable it is to be lined with epithelium and the sooner the lining will form.

Pathology.—If we consider that an ulcer is a more or less flat concave lesion, and that fistula and sinus are tubular, there is no pathologic distinction. There is a fibrous tissue base of new formation surrounding the canal. This scar-tissue, just as in chronic ulcer, may interfere with healing, especially if a tubercular or syphilitic infection is present. The surface of the lumen may be covered with granulation tissue, completely, partially, or not at all. The areas not covered with granulations show necrotic tissue. Sinuses present at times a peculiar aspect at their opening into the integument if they are chronic and persistently open. The connective tissue contracts around the lumen, and the granulations, often unhealthy or hypertrophic, protrude in circular form around the opening. This has been named hen's anus sinus, and is usually seen in sinuses associated with chronic bone infections.

Diagnosis.—In the first place, it is necessary to determine the presence of fistula or sinus, and which of the two is present. The position of the opening may of itself determine which is present; on the other hand, the position might point equally to the two conditions. If by passing a probe into the canal it can be made to pass through the deeper end of the canal on to a surface or into a normal cavity, the question is settled. But the devious routes of the canals often render it impossible to follow them to their terminus, or the site of that terminus may be so situated as to preclude the possibility of recognizing such a passage, as would be expected from a known pathologic process which would indicate sinus; but in those cases where the opening is small, and the normal contents of the cavity hard and too large to pass, only such fluids as might escape through the lumen under normal circumstances, as in diarrhea in the instance cited, and the discharge from the mouth of the fistulous lumen would appear, and hence differentiation by this means is impossible. The passage of the contents of normal cavities through the normal or abnormal outlets of other organs is positive proof of fistula, as of passage of feces in the urine or urine by the rectum. This may occur in sufficient quantity to cause very distressing symptoms without the surgeon being able to prove it satisfactorily. The opening should be searched for, then, by endoscopic methods, if they can be applied; it is wise, when possible, to determine the exact point of each opening of a fistula, unless the canal is necessarily so short that discovery of one opening fixes approximately the site of the other. Even with this, it may still be impossible positively to diagnosticate fistula, and resort must be had to the very simple and effective injection of some harmless, but easily recognized, fluid into one cavity and determination of its passage into the other or upon the surface. Sweet milk, solutions of potassium permanganate, or of methylene-blue are most frequently employed. Such a method will determine positively that fistula is present, but, unless observation can be made directly of its passage, it gives no further information. The passage of normal contents of one cavity through the outlet of another may be uncertain, and yet the discovery in the second cavity or its outlet of a pathologic product belonging only to the former gives positive information. Thus, I was able to ascertain the presence of a fistula between the intestine and the urinary bladder of a young girl in whom there was no proof of urine passing into the rectum or of feces through the urethra, but who discovered a large lumbricoid worm crawling out of the meatus urinarius.

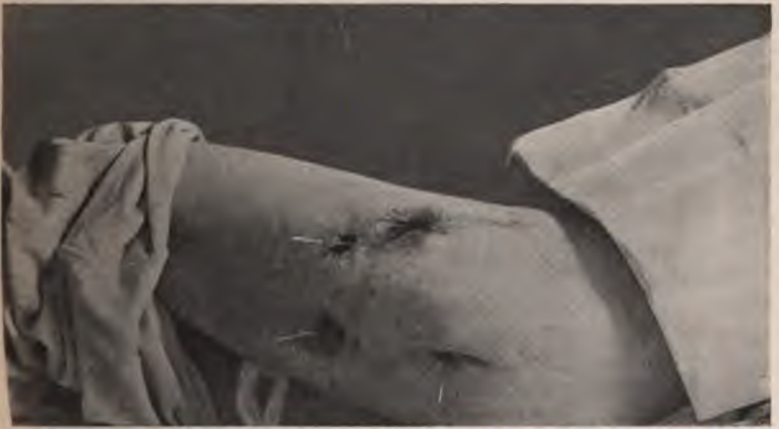

Fig. 39.—Tubercular sinuses of hip. Straws show direction of sinuses.

Sinuses are usually found opening on accessible surfaces of the body. Their outlet is no index to their source or course or depth. The route may be very short and direct or very long and devious, so that occasionally question will arise as to what and where the causative pathology is. A complete history should be obtained, and such evidence as scars and abnormal structures, previous operations with buried non-absorbable sutures, should be taken into account. No assurance can be placed upon the stoppage of the probe unless by it a pathologic process or a foreign body can be located. Occasionally multiple sinuses are present, and, by studying the group, more accurate information may be gained. Injection of the sinus with bismuth paste (Beck's) until the cavity is filled, and subsequent skiagraphy of the part, gives most satisfactory evidence, as by this means the course and length and ramifications of the channel as well as a certain amount of evidence, positive or negative, of the underlying condition may be determined. So, also, the nature of the discharge may at times help materially in settling the nature of the underlying lesion.

Treatment of Sinus and Fistula.—Unless the pathologic condition underlying sinus can be relieved or removed the sinus is incurable. If by delay and non-operative treatment there is probability that the causative pathology can be relieved, or that the foreign body will escape through the opening, it is better to wait; this is all important where delay is not dangerous, but where operation for radical cure is attended with much risk. When one does not know the definite location of the maintaining cause a sure way to find it is to follow the sinus, unless its course renders such a procedure impossible. When the lesion is reached it is to be dealt with radically, and treated subsequently by packing and healing by second intention, or if possible—it is usually not—the whole pathologic tissue may be removed in such a way as to get primary union. The fibrous tissue and unhealthy surface of the sinus with the contracted vent must be curretted or dissected away. This should be done habitually; it is imperative if healing by first intention is desired.

In those cases where delay is thought advisable, in non-operative cases, and in all cases where operation would be dangerous or mutilating, and in all where no great amount of diseased tissue is suspected, it is advisable to inject Beck's bismuth paste into the sinus, as many cases are permanently cured by this method, particularly tuberculous sinuses. The fact that a sinus has continued long, even though for years, is not a contra-indication, for the incredible results from employment of this method demand almost that it be employed prior to undertaking operative treatment. Beck's paste is made according to two formulæ:

Formula for skiagraphy and early treatment:

Bismuth subnitrate	30 parts.
Vaseline alb.	60 parts.

M. et ft. unguentum.

Formula for late treatment:

Bismuth subnitrate	30 parts.
Vaseline alb.	60 parts.
Paraffin mollis	5 parts.
Ceræ	5 parts.

M. et ft. unguentum.

It is evident from the formulæ that the latter forms a harder paste. Some surgeons prefer to use the first formula for all cases, with apparently good reasons, and some reduce the quantity of bismuth—bismuth 30 to 40 parts, vaselin 100 parts—and substitute the subcarbonate of bismuth for the subnitrate recommended by Beck, as the subcarbonate is less toxic.

When this treatment is contra-indicated, and at what stage in the course of the disease it is best to employ it, are two important and as yet not thoroughly settled questions. It can hardly be claimed that the method is contra-indicated in any case, but there are necessary precautions and modifications. If there is a large amount of purulent discharge, or if the patient shows poor vitality, it is necessary to reduce the discharge and build up the general vitality before making a large injection, but small quantities of the paste may be used with safety, often with advantage, and, when improvement is sufficient, larger quantities can be used. The most favorable cases are those in which the discharge is not purulent or but slightly so. The cases showing the greatest percentage of failure are advanced cases of bone and joint tuberculosis (spondylitis and coxitis). The secretions should be sucked from the sinus by cupping before injection is made. If the sinus bleeds, postpone the injection for twenty-four to forty-eight hours.

The paste must be warm enough to be forced easily through a glass syringe. A catheter of suitable size is inserted to the bottom of the sinus and the deposit made through the catheter, filling the cavity from within outward. If the cavity is large it is better not to attempt too large a dose, but to employ safe dosage (10 to 30 c.c.) and repeat at a future sitting. It is preferable that the sinus should be filled with paste, as will be indicated by complaint of pain by the patient, but an excessive quantity should not be attempted. After a satisfactory injection one may wait for ten to twenty days before making a second, or, if there is evidence that the paste has largely escaped, it may be repeated in a few days.

Bier's hyperemic treatment may be used with advantage in cases where its application is possible, but if the real lesion is far removed from the mouth of the sinus cupping can be of little advantage, and if the lesion is not situated on an extremity hyperemia cannot be produced by the tourniquet.

Treatment of Fistula.—The methods of treating fistula are very simple, but their successful performance is one of the most difficult tasks of the surgeon, often followed by failure, while a few present hopeless defects. The treatment of fistula may be classed as follows: (1) Direction of the maintaining cause through other normal or artificial channels. (2) Excision of the fistulous tract and suture. (3) Removal of the structure from which the secretion enters the fistula. (4) Slitting up the fistula. (5) Duct transplantation.

(1) In case a fistula is of small caliber and not healed open, if the tissues are healthy, cure may usually be accomplished by prevention of the passage of substances through the opening. This presupposes that all obstruction to the exit of normal contents of the viscus shall be removed, and that no accumulation of normal contents be allowed to distend the viscus, or that the same end shall be accompanied by the creation of an abnormal vent at a more favorable site. If the fistula has previously healed open, or if a large amount of scar tissue surrounds the tract, failure results. As an illustration, take a fistula leading from the bladder to the skin of the abdomen. When the urethral obstruction, usually stricture, is removed and a self-retaining catheter is introduced, or when a perineal cystotomy or external urethrotomy is done and a drainage-tube placed in the bladder, the fistula should heal.

(2) In other instances it is necessary to excise the fistulous canal and all surrounding scar tissue and suture. This is necessary in all cases of fistula that heal open. If there is no scar tissue, excision may be unnecessary; however, the edges should be scraped down to healthy tissue. This method depends very largely for its success upon primary union, at least of the rent in that viscus from which the leakage occurs. If two communicating surfaces lie close together their walls must be dissected away from each other, so that they may be closed independently; it is preferable, where possible, to close the opening in one in a direction at right angles to the line of closure in the other. In all instances the dissection should be extensive enough to allow the edges of the fistula to be approximated without tension, as tension on the sutures and tying sutures sufficiently tight to cause necrosis of the tissue within their grasp is a certain cause of failure. A viscus cannot be permitted to functionate until after healing occurs, as it makes traction on sutures, forces contents through the line of union, and carries or favors infection. So in vesicovaginal fistula the edges are freshened, the two walls dissected apart, each sutured independently of the other, and catheterization done at regular intervals of a few hours or continuously.

(3) In case the fistula is so situated that it cannot be relieved

by other procedures, or the structure from which the discharge comes is incapable of further useful function, it may become necessary to remove the structure responsible for maintenance of the fistula. For example, fistula from the parotid gland or from obstruction of Stenson's duct, and gall-bladder fistula due to permanent obstruction of the cystic duct, may require to be treated by excision of the structure named.

(4) Certain fistulæ are situated so that they can be treated by slitting the whole canal open, thus converting it into an incised wound, removal of all the diseased tissue as well as the cicatricial tissue, and packing the wound open so as to get healing by second intention, or, more exceptionally, suturing for primary union. An absolute essential in this class of cases is that the whole of the fistulous tract, with all ramifications, however minute, shall be discovered and slit open. This is the usual treatment of the most frequent form of fistula, namely, fistula in ano.

(5) In all cases of duct fistula the plan of transplantation of the duct may be done, provided the duct is of sufficient length to admit of such a method. So in case of a ureteral fistula the duct may be transplanted into the bladder at a favorable point or into the rectum, and in fistula of Stenson's duct either the duct may be transplanted or a new duct made by infolding buccal mucous membrane.

CHAPTER X

ERYSIPELAS

Erysipelas is an acute inflammation of the lymphatic structures of the skin and mucous membrane produced by streptococcus infection, and characterized by its rapid onset, marked constitutional symptoms, abrupt delimitation of the inflamed areas, and its tendency to recurrence.

Etiology.—The cause of erysipelas has been given until recently as the Streptococcus erysipelatis of Fehleisen. Recent investigations do not confirm the older belief that erysipelas is produced by a specific streptococcus, but show rather that the disease may be produced by ordinary pyogenic streptococci, whose behavior and virulence vary, and which may produce pus or not according to their peptonizing power, which, in general, does not equal that of pyogenic staphylococci. Streptococci soon lose their vitality in cultures, but are preserved by cold.

Reduced vitality, anemia and exhaustive diseases, severe trauma, and hemorrhage predispose to erysipelas. The universal distribution of streptococci renders infection easy, and it is surprising that erysipelas is not more common than it is. The fact that an individual is suffering from other streptococcic infections or has erysipelas does not afford immunity, but seems rather to predispose to erysipelas.

Atria.—Erysipelas always follows the introduction of streptococci through an atrium. The atrium may be so slight as to escape the notice of the patient, or concealed so that it cannot be easily discovered, whence the adoption of the term "idiopathic erysipelas" of the older writers. Ulcers, wounds, abscesses, sinuses and fistulæ, hang-nails, and fissures all are favorable atria. These may be situated on the surface or may be on the mucous membrane, especially of the mouth or upper air-passages, a fact which explains the so-called idiopathic facial erysipelas. In erysipelas neonatorum the bacteria enter at the unhealed navel of the newborn. Cases develop at the site of puncture of the skin when aspirating infected cavities, as in synovitis and pleuritic effusions. The genital tract of the parturient woman offers an especially inviting field for streptococcus infection, and consequently one of the most fatal types of puerperal sepsis arises. Although erysipelas usually appears first near the atrium, the inflammation may be remote from it; it may be conveyed from a deep focus through the blood (hematogenous).

Pathologic Changes.—The local process shows the usual changes of an acute inflammatory condition. Streptococci are found in great numbers, especially in the lymph-spaces and small lymphatic vessels of the integument and the subtegumentary tissues. They may so abound as actually to block the channels. The bacteria are more abundant and more active in the borders of the inflammation and are fewer or entirely absent in the older central areas. Minute abscesses may be present in great numbers. Diapedesis and exudation are present, the latter in great measure in the regions abounding in loose cellular tissue. Occasionally bacteria are found in surrounding uninflamed tissue, and rarely are recoverable from the blood. In the phlegmonous type, necrosis, especially of the connective tissue, may be extensive, and pus is found with or without mixed infection. Blebs may be found over the inflamed surface, which usually contain serum, occasionally pus. The hair may fall from the follicles due to separation from the papillæ by cellular infiltration. There is a greater proliferation of connective-tissue cells than in ordinary infections.

Local Signs and Symptoms.—The local inflammation may appear either before or subsequent to constitutional symptoms. The inflamed area shows a bright-red color and rapidly spreads by continuity. The appearance is that of a violent inflammatory process. The most distinctive feature of this inflammation is that it terminates abruptly; there is no shading off of the redness into normal tissue, as is seen in ordinary inflammations. There may be red streaks over the larger lymph-channels leading from the affected area and the edges of the inflamed tissue are raised slightly, but perceptibly, above the surrounding level. In the central part the swelling may be so great as to render a small surface anemic, giving it a whitish or yellowish-red appearance. Blebs may form on the surface and occasionally are numerous; they usually contain clear serum, but at times pus. When they rupture, their surface may become dry and a thin scab form. As the inflammation subsides desquamation takes place, and now and then alopecia is observed. After from two to five days the inflammation subsides at the point first affected, but may extend at the same time into the surrounding zones, and may, before recovery, return to the site of the beginning. The affected area is indurated. This extension is not uniform in all directions, but may affect any adjacent surface. When an erysipelatous infection is spreading in the skin it often terminates abruptly at a dense portion of the skin or at anatomic lines, along which the skin is attached tightly to underlying structures. Thus, in facial erysipelas the tip of the nose and the chin usually escape. The anatomically related lymph-nodes become more or less enlarged.

The swelling of erysipelas is very variable, dependent upon the virulence of the infection and particularly upon the region affected. The looser the subcutaneous tissue, the greater the swelling. It is at times so great that the entire outline of the part is destroyed.

Burning pain is complained of, and the inflamed surface is sensitive to pressure or manipulation, but in the milder cases only a slight discomfort may be felt.

When a wound or ulcer that has been suppurating is attacked by erysipelas the discharge is reduced or ceases entirely, the surface becomes dry and of a glazed appearance, and if healthy granulations were present, they become unhealthy and swollen. In wounds healing by first intention the mechanical bond of union is interrupted and gaping results. At the beginning of involvement of the surrounding skin there usually appear red streaks, leading away from the margins.

General Symptoms.—The period of incubation is short, and ranges from fifteen to sixty-one hours, as determined by Fehleisen in fruitless experiments for therapeutic purposes.

Following a period of incubation of fifteen to sixty-one hours the general symptoms of erysipelas are ushered in with a chill; there is almost no exception to this statement. The temperature rises always to a moderate elevation, but frequently to a very high degree. Usually ranging from 101° to 103° F., it occasionally reaches 106° F. The temperature is remittent in type, and the normal line may be reached as the local inflammation subsides at the expiration of a few days, but this is no assurance that it will not rise again. Recurrence of the chill usually signifies invasion of a new field, and is followed by another rise of temperature; but the chill may recur even daily, without evidence of extension. These variations may recur several times before recovery. The pulse runs *pari passu* with the temperature, but, in asthenic patients and those suffering from violent infections, becomes rapid, weak, and irregular, a very ill omen. Headache, malaise, anorexia, and, in the severe cases, nausea and vomiting are present, and prostration is out of proportion to the local inflammation. Diarrhea may be present, but is not constant. The nervousness and restlessness are at times so marked as to require especial consideration. Delirium is not infrequent. In cases terminating fatally, delirium is followed by coma and death. The duration of an attack is from seven to fourteen days.

The chart of erysipelas very closely resembles that of lobar pneumonia. The initial chill, the continuous fever, and termination by crisis shows their marked similarity. Either of them, on the other hand, may terminate by lysis.

The leukocyte count is variable and valueless. Polymorphonuclears are usually slightly increased, more so if pus is present, and eosinophiles are reduced at the height of the disease.

Types of Erysipelas.—The following terms are descriptive of the appearance of the inflamed part and of the exact pathologic stage reached. They are not exclusive, for any of them may be converted into any subsequent one in a few hours. They are erysipelas erythematosum, erysipelas vesiculosum, erysipelas pustulosum, and erysipelas phlegmonosum. The former three affect only superficial structures, but the phlegmonous type affects superficial and deep structures, and behaves as a violent cellulitis, producing necrosis and suppuration of the deeper tissues, especially the deep connective tissue, and burrowing extensively among the anatomic parts.

Another type will be met with rarely, viz., the fulminating or gangrenous; gangrene is produced by the dense infiltration (Kaufmann), aided, of course, by the toxins.

Wandering Erysipelas (Erysipelatis Migrans or Ambulans).—This type of erysipelas, by its wide extension, is capable of continuing longer than any other. It gradually extends from the site of primary infection and along the surface until, spreading by continuity, it has progressed from one hand to the other, or from the face to the abdomen or thighs. The area first infected is usually healed long before the limit is reached. It may continue for many weeks, but is usually produced by a mild type of infection and does not produce severe constitutional symptoms.

Metastatic Erysipelas.—This type of erysipelas produces secondary areas of infection, often remote from the primary spot, and this without direct infection through a new atrium. The spread is unquestionably hematogenous, and, for this reason, must be looked upon as being, if not more severe, at least of more uncertain prognosis. The only case of metastatic erysipelas I have seen was an old, feeble patient, who died four days subsequently to the appearance of the secondary patches.

Recurrent Erysipelas.—This term is applicable to those cases which, having recovered from an attack, are prone to develop subsequent infections from the same source, and may be attributed to infection from some lesion which harbors the micro-organisms. Such lesions are fissures, chronic ulcers, and sinuses or fistulæ. One of the most frequent sources for this infection is necrotic and carious bone, whose sinuses constantly discharge their contents on the surface. Even after the sinus has healed temporarily the first evidence of reopening may be the appearance of an erysipelatous patch around its mouth.

Habitual Erysipelas.—This signifies the continued presence of infection about the body without a discoverable lesion and a well-marked predisposition toward these bacteria. It is usually facial, and may be brought on by the slightest provocation. It seems that the infection awaits constantly the least abrasion about face, nose, or mouth, and will not fail to enter the least scratch or abrasion that may be found. It is more frequent in alcoholics. Such cases are not especially favorable for operative work in the field concerned.

The last two classes illustrate well how little streptococci are capable of minimizing their host against further invasion.

Facial Erysipelas.—*Erysipelas of the head* usually affects the face. The scalp and nape of the neck are frequently attacked. The atrium of infection in facial erysipelas is frequently situated within the nose, mouth, or the accessory sinuses. The swelling is often intense, owing to laxity of the connective tissue; this is especially true of the eyelids, which may become so swollen as to close the palpebral fissure, not only so that voluntary opening of the eyes is impossible, but even passive exposure of the bulb is difficult. The size of the head in extensive facial erysipelas is markedly increased and the individual is often unrecognizable. The tip of the nose and the chin usually escape the infection. Erysipelas of

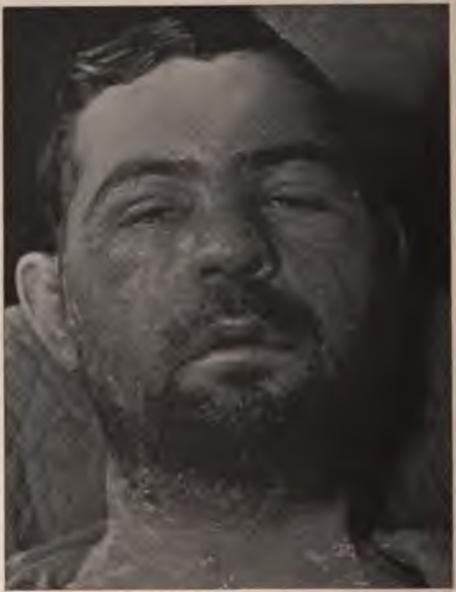

Fig. 40.—Beginning case of facial erysipelas.

the face may be unilateral or bilateral. Occasionally the mucous membrane of the upper air-passages or of the mouth, pharynx, or larynx will become affected, and the latter are always of the gravest import, for the intense swelling, when it reaches the fauces, may extend to the vocal cords and result in asphyxiation by edema of the glottis, or produce a very sinister effect on deglutition by swelling of the pharyngeal mucous membrane.

The constitutional symptoms are, *cæteris paribus*, more intense in facial erysipelas than in that of other regions, and the mental symptoms of nervousness, stupor, delirium, and coma are found in a higher percentage of these cases. Cerebral complications are likewise more likely to develop in the facial type.

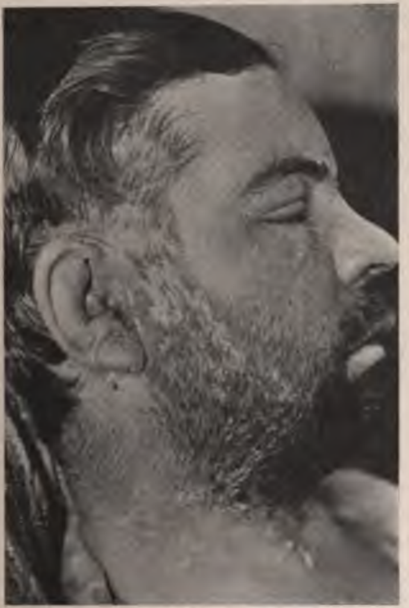

Fig. 41.—Same as Fig. 40, side view, showing blebs in ear.

Erysipelas Neonatorum.—In the newborn the infection must gain entrance before complete cicatrization of the navel, which serves as an atrium. Since the inauguration of antisepsis and asepsis in obstetric practice the occurrence of this fatal type, as well as of the remaining types, has been very materially reduced, and many physicians of extensive experience have never seen a case. Erysipelas neonatorum is frequently coincident with puerperal sepsis in the mother. It occasionally assumes a phlegmonous or gangrenous form in the advanced stages. Arteritis and phlebitis are frequently associated, and extension along the veins may lead to infection of the liver. The peritoneum and pleura also may become inflamed. Death usually occurs at the expiration of a week or ten days.

Epidemic Erysipelas.—No recent outbreaks of epidemic erysipelas have occurred. The last epidemic in the United States was in 1842 and was of the most malignant nature. Owing to the frequent involvement of the tongue the disease was named "black tongue." There had been several epidemics in the various countries of Europe during the preceding century. Epidemic erysipelas is more severe than sporadic cases.

Complications.—While they do not occur with great frequency, there are several possible complications, and they are often infinitely more serious than the disease itself.

Septicemia.—Septicemia, in its most typic and virulent form, may arise as a complication of even a mild case of erysipelas, though it is more likely to come in the severe cases. With it comes an increase in the severity of the symptoms and the hopelessness of prognosis. Streptococci are not recoverable from blood of the usual case of erysipelas, but in septicemia they may be; but, whether recoverable or not, the pathologic findings show abundant evidence that hematogenous distribution of the bacteria has taken place.

Endocarditis and Nephritis.—Even when sufficient numbers of bacteria have not entered the blood to establish a true septicemia, enough are often conveyed thus to inaugurate inflammatory lesions of the heart, of which endocarditis heads the list in frequency. Again, the lodgment of bacteria in the kidneys during the efforts of the latter to eliminate them from the general circulation may result in a more or less intense nephritis. This does not prove that septicemia has complicated the case, for, as has been shown elsewhere, there are all degrees of bacteremia in localized infections, and only after a certain dosage has been reached can septicemia be established. This complication calls for most attentive supervision subsequent to recovery.

Pneumonia.—Streptococcus pneumonia, possible in any case of erysipelas, more probable when a large hematic infection is present, gives evidence of pulmonary involvement, and, while the signs may be confined more or less to definite areas, one is more likely to find both lungs universally affected. The usually typic picture of lobar pneumonia is wanting, and the general and local condition is more like catarrhal pneumonia.

Meningitis.—This complication is occasionally met with in infections of the head, face, neck, and mucous membrane of the mouth, throat, and nose. It is due to extension along the lymphatics or veins to the meninges.

Phlebitis and Thrombosis.—These complications may occur at any point, but they are more likely in erysipelas of the lower extremities, due probably to the relatively poor circulation of the superficial veins of these parts. Extension through the emissary veins to the cerebral sinuses may occur in erysipelas of the head and face. It is not even necessary to mention the gravity of such a complication.

Lymphangitis and Lymphadenitis.—The unique feature of erysipelas is its affection of the superficial lymph-spaces and vessels. It is only a step further to inflammation of the large lymph-channels. This often happens, and it is the rule to find enlargement of the lymph-nodes receiving drainage through the affected field. These occasionally suppurate and demand treatment accordingly. They usually subside without suppuration when the local condition is relieved.

Sequelæ.—Attention is directed to two rare sequelæ of erysipelas. The first is elephantiasis. This condition follows only after repeated attacks. It is seen in the face, giving it a mask-like appearance, and is sometimes seen in the lower thigh in cases of ulcer of the leg.

The second sequela is blindness. This follows facial erysipelas and is, fortunately, very rare. It occurs in one of two ways: first, by "a trophic degeneration of the optic papilla," or, second, "by panophthalmitis with suppuration and destruction of the eye itself" (Foster). In other words, it is a phlegmonous inflammation of the eyeball and possibly of the other orbital contents.

Diagnosis.—There is little possibility of mistaking erysipelas when it appears with its typic features. The redness, induration, elevation, abrupt borders, and constitutional symptoms of initial chill, followed by fever, make a picture not seen in other diseases. The chart alone would lead one to think of lobar pneumonia, but the distinction is cleared by physical signs. The occurrence of chill and fever in a patient who has had a recent wound should lead to a thorough investigation at once. The claim is made that a pathognomonic evidence of erysipelas is failure of the temperature to drop on the morning of the second day below what it registered on the evening of the first. Ordinary inflammatory processes involving the skin and underlying tissues are not essentially lymphangitis. When suppuration appears it is probable that erysipelas is not the cause. Erythemata, both septic and non-septic, produce redness, but the other characteristic signs are wanting. The ephemeral nature of many erythemata is important negative evidence.

Prognosis.—The outcome of erysipelas is usually favorable, but where it occurs in the very young or the very old and feeble it is much more grave. There is a special danger when it affects parturient women, as sepsis will rarely be avoided. Complications with pneumonia, septicemia, and thrombosis of cerebral sinuses renders the prognosis exceedingly grave.

Treatment.—The treatment of erysipelas is prophylactic and curative, the latter being subdivided into local and general.

Prophylaxis.—Asepsis is the habitual means used to prevent erysipelas, but imperfection of technic renders it obligatory to isolate every case of erysipelas as soon as the condition is suspected, and to allow no one to come in contact with other surgical or obstetric cases while attending upon erysipelas. There should not only be isolation, but nothing should be allowed to pass from the patient to the kitchen or other departments of the hospital without sterilization. The physician who is compelled to dress the case should be excused from contact with any patient to whom the infection may be transmitted. It is better that all dressings be made by an assistant or nurse, or that the case be turned over to some young physician who can attend it without great danger. Obstetrics and surgery must not be done by the attendant. The nurse and attendant should take care that no wounds are present on their person during attendance. If the physician in charge is so situated that he cannot escape a case of erysipelas; and must continue with his practice, the best he can do is to robe himself and wear rubber gloves during the dressing, and it would be better for him to change his clothes out and out. After recovery, the patient, all attendants, and the room with its contents must be sterilized and all clothing changed; in all cases of erysipelas in hospitals no orderly or nurse should be permitted to render service to the patient unless they can be made clearly and intelligently to understand the danger and the restriction.

Local Treatment.—Numerous remedies and procedures have been employed locally in the treatment of erysipelas, most of them perhaps of mediocre value when one considers that the disease itself is limited, and many of them are highly praised for their signal curative properties. There is no specific and nothing even approximating it.

It is best in cases of erysipelas affecting a hairy surface to cut the hair short. Shaving is unnecessary. The longer and thicker the hair, the more necessary it is to cut it, for it serves as an obstacle to local applications.

Perhaps the most satisfactory local application is ichthyol. It is used in the form of an ointment with vaselin or, preferably, lanolin as the menstruum, and is made in strengths varying from 10 to 50 per cent. The 50 per cent. ichthyol ointment in lanolin is probably the best treatment so far discovered. The skin should be washed with a non-irritating soap and warm water and dried before applying the ointment on gauze mats. The ointment should be applied at least twice in each twenty-four hours, and should not simply cover the inflamed spot, but must cover a surrounding margin of 2 to 4 c.c. It is superfluous to state that this treatment is not applicable to erysipelas of the mouth and air-passages. Bichlorid of mercury, in solution 1 : 1000, is perhaps the most popular treatment. Compresses saturated in this solution are applied and moistened at intervals of three to six hours as evaporation takes place. Carbolic acid, in 1 to 5 per cent. solution, is employed in the same way, with very satisfactory results, but the increase in strength by evaporation of the solution on the compresses, and the tendency to produce gangrene when applied continuously, must not be forgotten. If carbolic acid is used it is safer to change compresses each time rather than to pour the solution on.

Tincture of iodin has been extolled by some; the writer has had no experience with it. Besides being an antiseptic it has the additional advantage of counterirritation.

Besides local surface application, carbolic acid or bichlorid of mercury solutions have been injected into the skin just at the periphery of the inflamed spot, with the hope of checking the advance of the infection. Similarly, the surface has been encircled at the margin or slightly away from it on the healthy skin with lunar caustic; encircling compresses have been applied to occlude the lymphatic spaces, and incision through the skin has been done to interrupt the continuity of the spaces and allow granulations to develop before the infection reaches the line of incision. None of these treatments are widely employed and they cannot be recommended as being of especial service.

The constant employment of a saturated solution of Epsom salts in water has been experimented with, but the number of cases is too small to justify an opinion. If suppuration or gangrene occurs it is subject to the same rule here as under ordinary circumstances.

Inasmuch as erysipelas is an infective inflammatory process, it is very justly doubted by many if any of the above-mentioned methods are of value, and certain that some of them may do harm, either from toxicity or from local irritation and the production of eczema, as happens from the constant employment of aqueous solutions. Hence, the same local remedies are recommended as if the part were infected with other bacteria, for example, staphylococci instead of streptococci. Rest, elevation, the application of soothing lotions or ointments for the control of pain, and the employment of Bier's hyperemia; and, when the swelling is intense and necrosis imminent, the employment of incision or punctures; cold applications should not be made; they increase the danger of necrosis. No question can be raised that, with our present understanding of the etiology, pathology, and treatment of inflammation in general, the above is the rational course to pursue.

Constitutional Treatment.—Medicaments taken internally are just as worthless as those locally applied in the treatment of erysipelas, and the whole internal treatment may be summed up in the time-honored statement, "meet the indications." The important items are the perfect hygiene of the room, fresh air in abundance, pure water, careful nursing, and nutritious and stimulating food. The condition of the heart must be continuously and frequently observed, and signs of cardiac weakness or of reduced blood-pressure must be met promptly. Iron in large doses, frequently repeated, has long had great reputation in the treatment of this condition, and once was considered almost a specific. It is not; so whatever benefit occurs by its use depends upon its tonic action. Elimination of the poisons by natural channels is the greatest hope for benefit in internal treatment, and water in abundance, with as much assistance as the moderate use of laxatives offers, is the best remedy.

Serum Treatment.—This has proved so far unsuccessful, and, while its use may do no harm, it cannot at present be accepted as influencing the prognosis sufficiently to justify its administration. *A priori*, if we understand that erysipelas may be produced by any one of a vast number of streptococci, and that immunity against one obtains for that one and no other, and that it is impossible to recognize the strain in a specific instance, it is easy to see that, while a marvelous cure might be effected, the majority would not be benefited.

Curative Action of Erysipelas.—The occasional recovery of a tedious or hopeless pathologic condition led the profession to hope that a great therapeutic agent was to be found in erysipelas infections. Gumma, malignant tumors, especially sarcomata, and tuberculous ulcers have been known to heal permanently after being infected with erysipelas. Experiments were made by actually inoculating other patients, which proved more difficult than had been suspected. Several patients died of erysipelas and few recovered from their original disease. The hope was not sustained. Afterward Coley's fluid was used, and is at present used in the treatment of inoperable sarcomata. A very small percentage of cures have followed its use, and no deaths from the fluid have been reported. It gives the benefit, if there be any, without the danger of a vital infection, but it does not in any way replace the need for surgery in these cases.

CHAPTER XI

TETANUS, LOCKJAW

Tetanus is a specific disease produced by the bacillus of tetanus of Nicolaier, and is characterized by tonic spasms.

Etiology.—The bacillus of tetanus is a spore-producing anaërobe. The spore forms in the end of the bacillus and gives it the characteristic drum-stick appearance. Great numbers of the bacteria, perhaps the majority in a given field, do not show the presence of spores. The bacillus is a native of the soil, and is habitually found in the alimentary tract of the horse. It, therefore, appears with great frequency about stables and in gardens and fields where stable manure is used as a fertilizer. The bacilli also appear in great numbers in soil where refuse from the kitchen is thrown, and in dust, especially street dust. In the tropics the number of bacteria seems not only to be greater, but they are more virulent, as a far greater percentage of the total mortality is due to tetanus there than in higher latitutes, while a smaller percentage of recoveries occurs. Tetanus bacilli are occasionally found in vaccine virus, and several cases have been reported from the use of such virus. The method of preparation of the virus makes the demand for careful technic especially necessary, owing to the habitual association of the bacteria with dust, manure, and hay which has been cured on the soil. Furthermore, several cases of postoperative tetanus have been traced directly to an infected catgut which had not been freed by adequate sterilization from the bacteria it held, coming as it does from the alimentary tract of the sheep or other animals.

The fact that tetanus bacilli are anaërobes explains the relative infrequency of the disease, as it is incredible that no more wounds should be contaminated from this source. The usual type of wound causing tetanus is the punctured wound, less frequently contused wounds and abrasions. Injury to the tissues and the implantation of the bacteria into the tissues, so that oxygen cannot come in contact with them, are the two essentials. General resistance of the patient seems to play an important part in the etiology, as the individuals usually affected are the healthy, robust ones; they who are most liable to injury. There are fewer cases in the old than in the young, apparently for the same reason. Suppurative wounds seem more likely to cause tetanus, doubtless because

of the aërobic bacteria constituting the mixed infection. The destruction of oxygen by pyogenic bacteria renders the tissues more anaërobic. The bacilli are said to be more virulent in mixed infection especially with saprophytes. Similarly, in contused wounds the interference with normal circulation accomplishes the same end. It is not necessary that the wound should be large or deep; the extent of the injury bears no relation to the intensity of the disease. Superficial wounds and even abrasions and scratches, as well as hang-nails, are rarely atria for infection; these atria probably admit the germs into the lymphatics, and their lodgment in the nodes affords a satisfactory field for development. Occasionally tetanus develops in cases of simple fracture or contusion, explainable only on the ground of hematogenous infection. The so-called idiopathic cases are due to small wounds which have escaped observation or been forgotten, or to wounds of the alimentary tract infected by ingested bacteria. The presence of pyogenic infection or even of an inflammation of the wound is not essential, as has been abundantly proved by the development of tetanus in wounds healing *per primam* before the onset of symptoms. I saw a fatal case of tetanus recently in a man who received a slight abrasion, $\frac{1}{16}$ inch in diameter, while repairing a trace chain.

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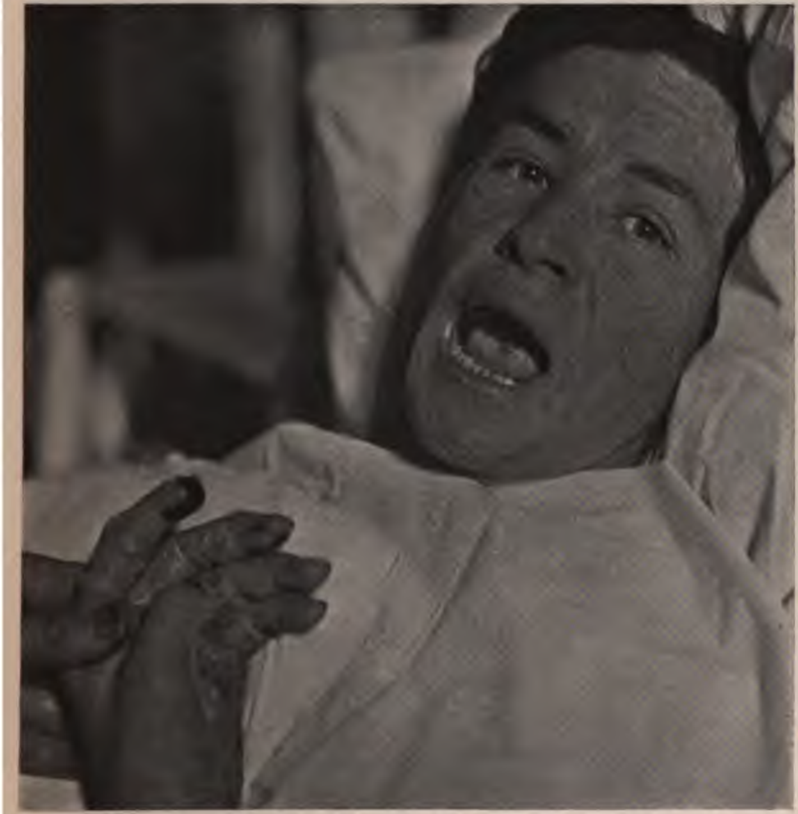

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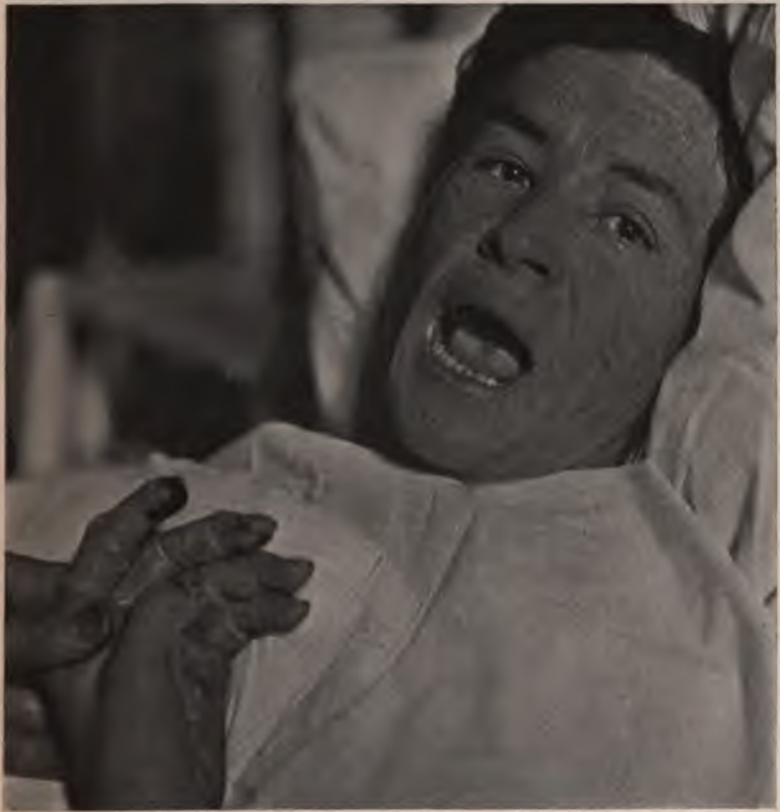

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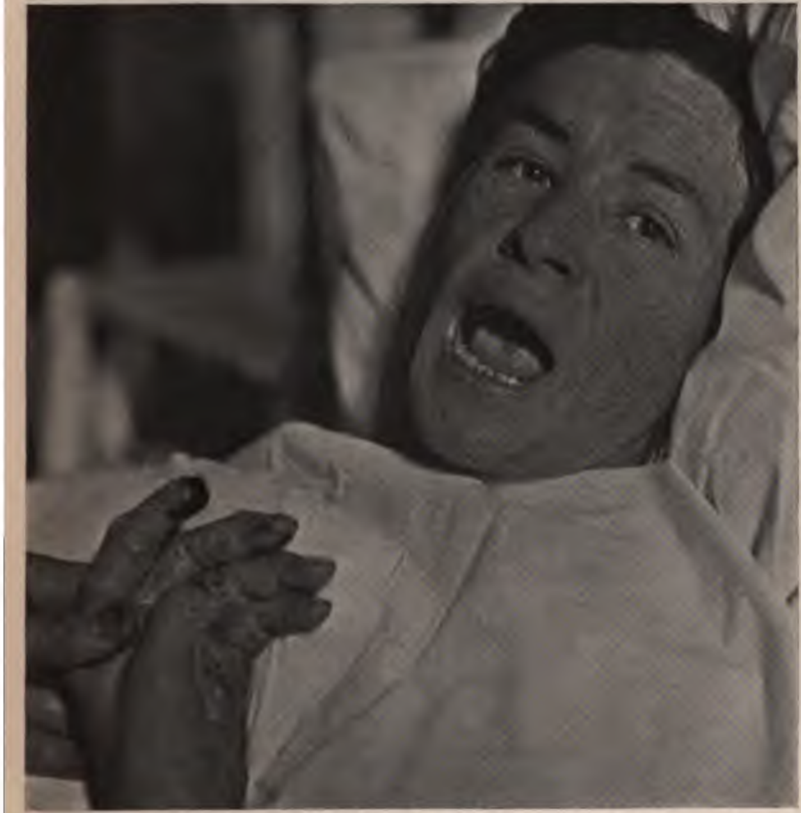

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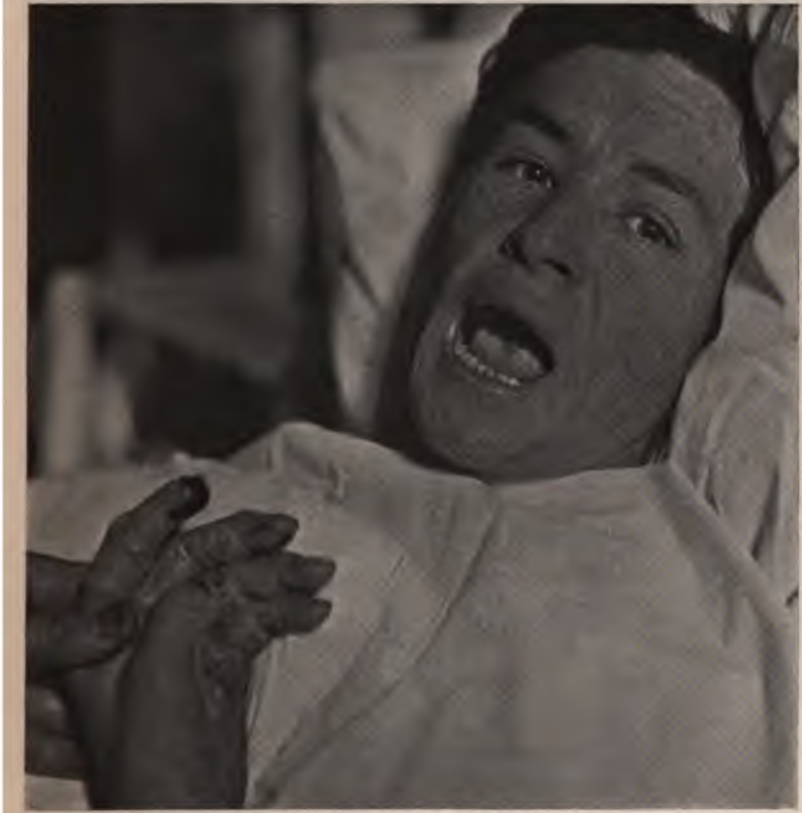

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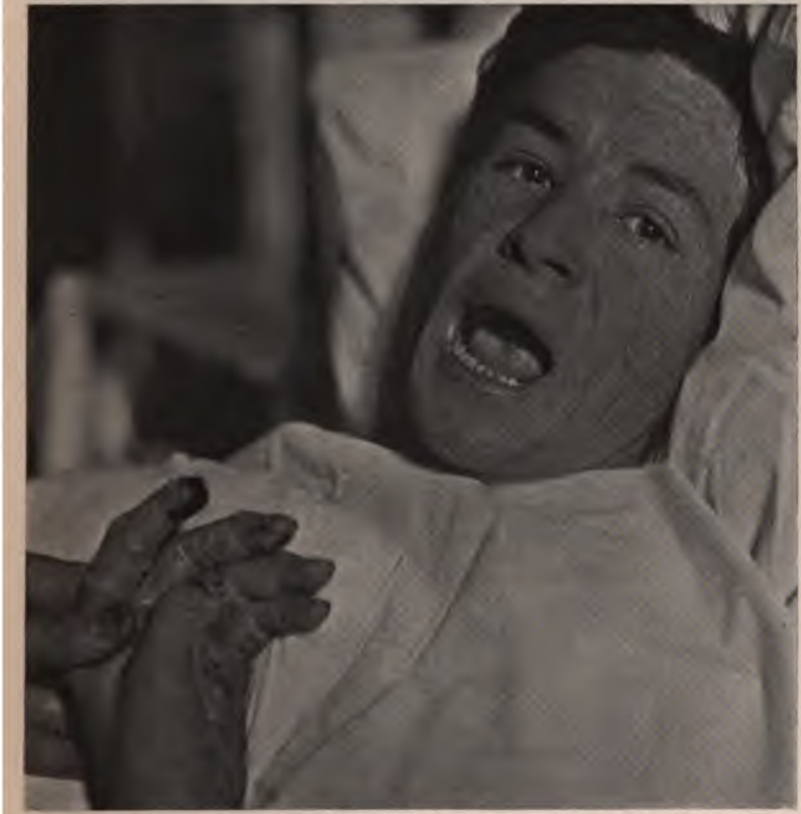

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within two weeks, and almost all the remainder either in the third or the fourth week. Occasionally longer periods are reported, the extreme time mentioned being eight and one-half weeks.

The beginning symptoms of tetanus are usually ascribed by the patient to a contraction of cold, which is felt as a soreness in the neck, or a stiffness in the muscles of this region. Further than this there is no discomfort. Then the muscles of mastication are involved, and, besides being sore, they contract so that the mouth can either not be opened or only partially opened. This symptom is called trismus. Then the voluntary muscles of the body become involved, and no group may escape, although the upper extremities are affected less than the remaining muscles and may escape altogether. I have not seen them free from contraction in any personally observed case. Involuntary muscles are unaffected.

The spasms are tonic, and while clonic spasms may occur when the muscles are first affected, they soon become tonic. They come on at the slightest disturbance of the sensorium, remain for a few seconds to a minute or more, and disappear. But the tone of the voluntary muscles is always exaggerated in tetanus, so that even between spasms there is an unnatural stiffness of the body. The slightest noise, touch, or light may call forth a spasm. The contraction may be slight in the milder cases, but in the severer ones the tension limit of the muscles is reached. Tendons are occasionally ruptured or pulled loose at their insertions and sometimes fracture is produced. The spasms produce soreness of the muscles. The peculiar expression of the countenance, known as *risus sardonicus,* or the sardonic grin, is produced by contraction of the facial muscles. It is more or less marked between the spasms, and intense and hideous during their presence. It is sometimes absent. The peculiar expression of the countenance, that of one straining every fiber of his being to lift an immovable burden, the clenched jaw, the dilated nostrils, the passage of the breath and froth through the occluded teeth, the eyes retracted into the sockets, and the countenance beaded or bathed with perspiration and of a cyanotic hue, the wrinkled skin of brow and cheek (tetano-facies), is a picture that no eye which has seen it could fail to recognize again. Not only so, the moaning of these patients during the spasms adds to the pity their appearance calls forth. The spasms affect the diaphragm, and, if the contraction of this muscle is intense, a pain along the origin of the muscle is complained of—it is the girdle pain.

Owing to greater violence in the contractions of various groups of muscles, the body assumes certain attitudes. The most common of these is *opisthotonos,* in which the body is arched with the concavity backward, so that if the patient lies upon his back only the occiput and the heels rest upon the bed. *Emprosthotonos* is the attitude of bending the body forward, due to excessive contractions of the recti abdominis. *Pleurothotonos* is bending of the body to either side; it is rare. *Orthotonos* is fixed rigidity of the body in the straight position.

The tetanus patient lies as quietly as possible, afraid to move, afraid to eat or drink, afraid to attempt relief of his bowels or bladder, for not only are these functions impossible or at least only poor, their performance, even each attempt at their performance, brings about a new general spasm. Hence, feeding the patient and quenching his thirst may become difficult problems, while relieving the bladder and rectum becomes at times well nigh impossible.

The temperature is an interesting item; it is slightly to moderately elevated, from 100° to 103° F., and, so far as treatment is concerned, is negligible. Toward the end of life the temperature rises very high, from 108° to 112° F., and may continue to rise for a time after death, although there is usually a drop just before death. The pulse, at first but slightly accelerated, becomes more rapid during the spasms, and, as the exhaustion increases, very rapid and weak. In cases whose circulatory apparatus is weak death may be attributable directly to accidents from this source. Rupture of a fatty heart has, for instance, been observed.

During all the painful spasms the unfortunate victim is doomed to remain conscious, and, while still exhausted from the last spasm, to dread the advent of another. They remain conscious usually to the end.

The termination of the hideous scene is a welcome to the sufferer and to his friends. Death is brought about by suffocation during a violent spasm of the muscles of respiration, by accidents to the circulatory apparatus, by sheer exhaustion, by paralysis of the heart, by aspiration-pneumonia, and by spasm of the glottis.

Types.—*Traumatic* tetanus is a term applicable to almost every case of tetanus seen in which wound infection has been produced.

The term *idiopathic* tetanus has been practically discarded. It was formerly applied to those unexplainable cases of tetanus where no atrium could be discovered.

Acute Tetanus.—In this type, to which the vast majority of cases belong, the period of incubation is less than fourteen days, and the duration of the disease is from one day to two weeks, usually terminating fatally. The symptoms are more violent, the course shorter, and the outcome much worse than in chronic tetanus. Rarely acute tetanus becomes chronic.

Chronic tetanus may follow acute tetanus, or the disease may assume the chronic type from the beginning. The symptoms are less intense and more prolonged, the period of incubation is more than two weeks usually, and the prognosis is far more favorable. It may last for weeks or months, and the contraction of the facial muscles may persist indefinitely in some degree after recovery.

Tetanus Hydrophobicus, Facial or Head Tetanus.—This peculiar type of tetanus follows infection in the distribution of the cranial nerves. It is afebrile. The onset is frequently preceded by paralysis of a cranial motor nerve, usually the seventh, but never the motor branch of the third division of the fifth. The paralysis always occurs on the side of the injury, and may antedate the onset of spasms several days. In the milder form the spasms affect only the distribution of the cranial nerves, particularly the muscles of mastication (trismus) and those of the larynx and pharynx, whence the name tetanus hydrophobicus. But in the more severe forms the disease may extend to the whole body, as in ordinary acute tetanus. Tetanus hydrophobicus is, as a rule, less severe, and offers a better prognosis than acute types.

Trismus Nascentium, Tetanus of the Newborn.—The atrium is the umbilicus or the cord. The disease is rare in modern obstetric practice. The period of incubation is from one to five days, and is in no important detail different from ordinary acute tetanus. The efforts of the child to nurse are eager, but the nipple is soon turned loose, for the attempt to swallow brings on the spasm. This type of tetanus is fatal, and the average duration of life is a little shorter perhaps than in ordinary acute tetanus.

Puerperal Tetanus.—This form of tetanus is likewise extremely rare; it is found more frequently in communities where obstetric practice is done by ignorant midwives, and in cases of criminal abortion, produced frequently by women inserting dirty instruments into their own uteri. In cases where laceration of the cervix uteri or the perineum occur, and where severe traumatism is done to the mucous and submucous tissues, these injured parts, as well as the endometrium, may serve as portals of entry for the infection.

Local Tetanus.—A few cases are reported in which tetanic spasms affect only the group of muscles supplied by the nerve which has conveyed the toxins to the cord centers. It is a mild form o tetanus, and has a favorable prognosis. It is very likely to be overlooked.

Diagnosis.—Tetanus may be confused with tetany, strychnin poisoning, hysteria, hydrophobia, meningitis, but a consideratio of the history and the mode of onset will usually make it possibl to differentiate tetanus from all other conditions. The finding o tetanus bacilli in the discharges from the wound is absolute proo of the nature of the disease.

Tetany is associated with disease or excision of the parathyroid glands, with dilation of the stomach, and gastro-intestinal disturbances. It is seen more frequently in the young, if cases due to excision of the parathyroids are excluded. It is not associated with a wound. It affects the muscles of the upper extremities more frequently and more extensively than the remaining muscles. The spasms are intermittent. It is more frequent in certain parts of the world. Four important signs serve to distinguish it from tetanus, any one of which may be wanting in a given case. The first of these is the position of the hand during the spasms; it is known as the obstetric (accoucheur's) hand, and is suggestive of the hand ready to make a vaginal examination. Second, is Chvostek's sign, which shows increased excitability of the motor nerves to mechanic stimulation; for example, tapping gently over the *pes anserina* produces spasms of the muscles supplied by the facial nerve. Third, Erb's sign is the increased electric excitability, especially to the galvanic current. This is true for both motor and sensory nerves; muscular response can be produced by the employment of currents varying from 0.5 to 2 ma., which, under normal circumstances, fails to stimulate contractions. Fourth, Trousseau's sign. This consists in making pressure over the nerves or blood-vessels supplying an extremity during the interval between spasms, and thereby evoking an attack. During the spasms their number is increased by the same maneuver.

Strychnin-poisoning is distinguished by the history of taking poison, by recovering it from the stomach contents, by the absence of a gradual, slow, definite method of onset, by the green border to objects of vision, by the rapidity of progress, and by the appearance of violent convulsions from the beginning; the absence of a wound, or, if one is present, failure to find tetanus bacilli. Evidence of gastric irritation is present in strychnin-poisoning. In strychnin-poisoning there are intervals of complete relaxation; they are absent in tetanus. Trismus is late in strychnin-poisoning and the eyes protrude during the spasm.

Hysteria usually gives a history of such attacks, and bears evidence of nervous phenomena not found in tetanus. The absence of trismus in the usual hysteric differentiates the two—if trismus is present, recurrence of the spasm is not rhythmic; the spasms are not induced in hysteria, as in tetanus, by slight sensory disturbances. The amenability of many hysterics to suggestion is characteristic. The spasms of hysteria may be prolonged much longer than those of tetanus, and relaxation in the intervals is complete. The absence of the sardonic grin and of untold suffering is significant; in hysteria the consciousness of the approaching spasm and the dread of the pain from it are not present as in

tetanus. There is invariably a betraying feature of the hyst
which a little attention and tact can detect, however closely it
simulate tetanus.

Hydrophobia.—The period of incubation of tetanus is m
shorter than that of hydrophobia, and this alone will, in the ma
ity of cases, even in those where tetanus results from a bite,
tinguish the two. Trismus does not occur in hydrophobia; o
thotonos rarely. The mental symptoms are marked in this dis
—restlessness, uneasiness, change of disposition, and delusions
common. The spasms usually begin in the larynx and phar
The spasms may be similar to those of tetanus—*i. e.*, tonic—
are usually clonic.

Cerebrospinal Meningitis.—This disease shows no trismus,
the rigidity begins in the neck. Headache, the history, the
pearance of delirium or coma, the changes in the fundus of
eyes, Kernig's sign, and gastric disturbances indicate mening
The withdrawal of fluid by lumbar puncture and discovery of
causative bacteria therein and improvement in symptoms
the puncture are pathognomonic.

Complications and Sequelæ.—Patients who have tetanus r
show complications, inasmuch as the bacteria do not affect
tissues directly or locally, but by the action of the toxins on
nerve-centers. Accidents may occur as a result of the se
spasms, such as fracture or rupture of various soft struct
The most frequent sequel is stiffness and soreness of the mus
This may last for several months. Rarely risus sardonicus s
persistent after recovery. Paralysis and mental disturbance
follow recovery, but they are infrequent.

Prognosis.—The chances of recovery from tetanus are
poor. The longer the period of incubation beyond ten days
better is the chance of recovery; also, the longer the disease co
ues beyond ten days the better the chance of recovery, and
reaches the fifteenth day each subsequent day adds greatly t
chances of recovery. Chronic tetanus offers a much better
nosis than acute. Acute tetanus (developing within ten days o
injury) has a mortality of approximately 80 per cent., but in ch
cases which have continued longer than fifteen days the mort
is something less than 10 per cent. The mortality is much le
cases which have had the disease fifteen days or more than in t
whose period of incubation has run the same time, 8 per
against 40 per cent. About 1 case in every 4 or 5 is chronic
out of 870) (Anders).

Treatment.—Treatment of tetanus is preventive or pro
lactic and treatment of the attack. The former is very effic
the latter very discouraging. Therefore it is necessary for

physician to determine whether the nature of a wound and the circumstances under which it was produced demand prophylactic treatment. Wounds soiled with earth or dust, those produced by objects which have been associated with stables or horses, or which have been in contact with the soil, those made on parts of the body that have possibly been soiled by tetanus bacilli, and those produced by toy explosives, all come under the suspicious group. More particularly, punctured wounds and contused wounds must be held in suspicion. Wounds made by rusty nails and tacks which have been lying on the ground or about the barnyard and garden are especially dangerous, but any punctured wound may carry infection from the shoe or the surface of the foot.

Preventive Treatment.—All suspicious wounds should be treated at the first dressing, so as, if possible, to avoid the development of tetanus. A great percentage of the cases of tetanus seen in private practice come from wounds which have received no medical attention. Hence, the physician should teach his clientele the importance of first-aid services in all wounds. If the wound is punctured, it should, under aseptic conditions, be converted into an incised wound and kept open by packing. All foreign material must be removed. In certain instances it is better to excise the whole wound and a sufficient width of adjacent tissue to make sure the infection is removed. The surface of the wound should be cleansed of all blood-clots and, particularly, of all devitalized tissue. Cleanse further by applying peroxid of hydrogen. This should be repeated at intervals, and the gauze packing should by preference be saturated with it. Apply an antiseptic solution continuously for fifteen to thirty minutes. Tincture of iodin applied to the wound surface is the most certain antiseptic. Five per cent. solutions of carbolic acid or lysol are perhaps the most widely employed agents, and the solution should be allowed to run into the wound and should come in contact with every crevice and corner. Afterward thoroughly dry the wound. The wound should never be cauterized either with actual or potential cauterants, as this may fail to reach all the bacilli, and renders the field unmistakably more suitable to the development of anaërobes. If pyogenic infection occurs, the pus should not be allowed to accumulate in the wound. In any instance, dressings should be made two or three times daily and fresh gauze introduced, either dry or saturated with iodin, or a solution of lysol, carbolic acid, or peroxid. Medicated gauze is worse than useless. The best dressing to apply is the powdered dry antitetanic serum. If this is used the dressings need not be repeated oftener than daily or on alternate days.

Prophylactic doses of antitetanic serum should be administered in absolutely every case, even if only slightly suspicious. In those cases where the bacilli can be demonstrated in the wound it is imperative. Fifteen hundred units of serum is supposed to be a preventive dose. Or, if not given in units, 20 c.c. or more may be given. The serum causes no evil results, save occasionally a cutaneous rash and soreness at the point of injection. Prophylactic doses are given usually beneath the skin. In very suspicious cases it is wise and safe to repeat the dose each day for two or three days.

Treatment of the Attack.—After tetanus has developed, the treatment is very unsatisfactory; and it is questionable if treatment has so far changed the mortality materially, although encouraging results are occasionally reported from various plans of treatment but the number of cases is too meager to admit of even remotel accurate conclusions. All patients who have received suspiciou wounds should be instructed to keep in close touch with the physicians for at least two weeks, for the above treatment is not a infallible preventive of tetanus.

The question arises whether it is safe to admit a patient wh has tetanus into a hospital. If there is an open wound, admitted it is not safe. If there is no open wound, it is comparatively sa although tetanus bacilli have been recovered from the feces patients having the disease. This, however, may be accident as they probably are frequently admitted into the alimentary tra of healthy people.

After the tetanus toxins have combined with the central nervo tissues it seems impossible to free them; whether this is due to t fixity of the combination, or to the inaccessibility of these tissues the antitoxin circulating in the blood, is not known. Howeve it is necessary to neutralize the uncombined toxins by the administration of antitoxin. This has, for manifest reasons, proved t be more efficient when practised in the beginning of the disease during the first thirty hours. Antitoxin has been administere in the following ways: it may be injected into the subcutaneou tissues, as mentioned above; it may be administered intravenously it may be given by injection directly into the nerve sheath, with th hope of interrupting further transmission of the toxin along th trunk; it is injected into the dura mater of the cord, just as in spina analgesia; or it is deposited directly into the lateral ventricle of th brain by trephining a very small opening into the skull, 1 to 1 inches lateral to the bregma, inserting a needle vertically into th brain until cerebrospinal fluid escapes, which shows that the ventricle has been entered (Kocher). The dosage of the serum i tetanus is undetermined, but it seems necessary to administe large daily doses, or perhaps several smaller doses, and to continu its use until free from danger. The acute cases of tetanus seen not to be influenced by serum, and, as the chronic cases offer a better prognosis naturally, it has not been decided how much they may be helped by it.

If the wound has not received proper treatment from the beginning, or if it has been closed, the first step should be to open it or dissect it out, and treat according to the rules laid down under preventive treatment. Since demonstration of tetanus bacillus in the lymph-nodes has been made, it theoretically reduces the old method of treatment by amputation after the development of symptoms to the same value its practical results have shown.

It is necessary to place the patient under such surroundings as will least tend to excite spasms, for, while this cannot thwart them, it adds a little to the physical comfort. Especial attention should be given to the bladder and bowels, and they should be attended to regularly by a competent nurse. Although assistance along these lines will excite spasms, they will be far less frequent than the continual unsatisfied efforts of the patient would produce. Nourishment and drink must be given if possible, but if swallowing is impossible these should be given at regular intervals through a small stomach-tube.

Control of the spasms of tetanus offers great difficulties, and every known narcotic and sedative has been tried. The number giving the best results, usually poor at that, is small. It is probable that the drugs recommended as giving the highest percentage of cures have depended for their effect solely on their potency for control of spasm. At the head of the list stands chloroform, which, administered by inhalation, gives very satisfactory temporary control. Anesthesia is unnecessary, and the drug should be pushed only to the point of control. The chief objection to it is that it cannot be continued indefinitely, and the spasms recur shortly after its discontinuance. Opium (usually morphin given hypodermically) is very satisfactory, but must be given in heroic doses to relax the spasm. There are two objections to its use: first, the inhibitory action on respiration, and, second, the interference with elimination. Physostigmin is lauded by many as a most effective antispasmodic in tetanus, but, like all narcotics, must be given in enormous doses. Chloral hydrate in maximum dosage gives perhaps as good results as any drug; the daily amount needed to produce sleep in severe cases runs as high as 3 drams or more. It is more efficient when combined with morphin, and its depressant action on the heart must be counteracted by appropriate stimulation. Carbolic acid injected along the spine has been used, but only in a limited way. The employment of carbolic acid, injected hypodermically or intravenously in 1 to 3 per cent. aqueous solutions, has shown, in the cases reported by Baccelli, higher percentages of cures than any other treatment. Tetanus patients have great tolerance for this drug, and it is thought that many failures reported were due to insufficient quantities. The daily dose should run from ½ to 1½ gm. or higher, if the urine shows no evidence of poisoning. In moderately severe cases the mortality has been 2 per cent., and in very severe cases it has been as high as 18 per cent. The injections are repeated every two hours, and each dose is from 1 to 2 drams of a ½ of 1 per cent. solution. Willard H. Hutchings has reported a series of 6 cases of tetanus in which chloretone was employed to control muscular spasm. The dose employed was 30 gr. in whisky if given by mouth, in hot olive oil if by rectum. The antispasmodic effect follows either method with nearly the same promptness and it controls the spasm wonderfully. The dose, or a smaller one, is repeated when the spasm recurs; of the 6 cases reported by this author, 5 recovered, one of these dying, soon after recovery, as a result of perforative peritonitis.

The remaining item of the treatment is elimination of the toxins. This is done chiefly by administering water by mouth, by rectum, subcutaneously, or intravenously.

The treatment of tetanus, then, may be summed up in the following brief statements: (1) Remove the primary focus, or sterilize it. (2) Neutralize the toxins by repeated administration of antitoxin. (3) Control the spasms, preferably with chloroform, chloretone, chloral, or morphin. More cures follow control by chloral or chloretone. (4) The injection of carbolic acid. (5) Keep the emunctories active.

CHAPTER XII

RABIES, LYSSA, HYDROPHOBIA

Rabies is an acute, specific, infectious disease produced by an unknown cause, transmitted by the salivary fluids (usually) of mammalia, and characterized by clonic spasms, a rapid course, and a fatal termination.

The term "hydrophobia" is applicable only to rabies in man. Rabies has long been known to affect both animals and man, but it was originally thought not to affect man.

Etiology.—The actual cause is unknown. By the symptoms, transmissibility, and the fact that the cause can be destroyed by sterilization, light, and drying, can be eliminated from contaminated fluids by filtration through porcelain, and can be increased in virulence by successive inoculations of susceptible animals, it is determined unquestionably to be a parasite. Whether this parasite is bacterial or protozoic remains undecided; however, the easy destruction of the virus by quinin solutions have led some to conclude that the etiologic agent is a protozoön.

The causative agent is spoken of in medical literature as the virus of rabies. It is found in the saliva and salivary glands of animals suffering from rabies, and for twenty-four to forth-eight hours prior to the first manifestation of symptoms. The virus is also found in the saliva of man during the course of the disease, and inoculation of animals from this source produces the disease. Hence, although there are no cases reported in which man has become inoculated from man, the possibility of such transmission must be accepted and all precautions exercised to prevent it. The virus is found also in certain other structures, especially the central nervous system. It has occasionally been found in the milk.

For manifest reasons hydrophobia usually arises from bites, and these are usually made by the dog, owing to the intimate companionship between man and dog. The percentage of bitten individuals who develop hydrophobia is small, being probably between 15 and 20 per cent. The bite of other animals belonging to the canine and the feline species is responsible, too, for a considerable number of reported cases, and the percentage of infection is higher among some of these than in dog-bites. The highest percentage of inoculations occurs from bites of the wolf, then the cat, the dog, and other animals. The explanation of the small percentage of cases of hydrophobia resulting from bites is due to the fact that the teeth are cleansed in passing through the clothing, and to the bility of certain suspected animals not being rabid.

Bites received on an unprotected surface are much more l to transmit the disease than those through clothing, although are sufficiently dangerous. The worst of all are bites on the It is not necessary that the teeth should penetrate the skin; sion of the epithelium is sufficient; however, lacerated wound for obvious reasons, more dangerous.

The virus, when once deposited in the tissues, travels alon course of the nerves to the centers, and remains there for indefinite time before symptoms arise. The virus may re confined to the side bitten. This is the rule in cases with a period of incubation. In cases whose period of incubation is l the virus crosses to the side opposite the bite, and may be f distributed throughout the central and peripheral nerve struc of the body.

Severance of a nerve prevents spread of the virus pas severed point. For example, severance of the cord prevent tension of the virus from the upper to the lower segment, or versa.

Destruction of Virus.—The virus of rabies is destroyed b posure to heat and cannot withstand 60° C. longer than t minutes. Cold does not damage the virus, but seems rath preserve it. It is preserved in neutral glycerin for an inde period, preferably at a low temperature. Drying of the virus the tissues containing it destroys its virulence directly in propo to the length of time it is dried, until, by the end of fourte fifteen days, the virulence becomes nil. Pasteur based the t ment for prevention of hydrophobia on this fact. If the ti containing the virus during the process of drying are in very pieces or in thin slices the virus is destroyed in a few days. light destroys the virus in forty hours.

A practical observation should be made here concernin carcasses. All animals dying of hydrophobia should be dest by burning, not by burial, as the environment of the buried is such as to maintain the inoculability of the virus indefin and other animals preying on these dead bodies are likely to de the disease. Furthermore, the presence of such bodies may taminate surface water, in which the virus may continue t for some weeks.

The usual antiseptic drugs—bichlorid of mercury, ca acid, and formaldehyd—destroy the virus. It is, further destroyed by solutions of uric acid, 1 : 16, and by bile.

Pathology.—The pathologic changes found in subjects of hydrophobia are few and inconstant. Most, if not all, c gross changes result from the spasms and are not characteristic. The viscera, both thoracic and abdominal, show congestion. This is more frequent in the kidneys, spleen, and lungs. Emphysema may be present. The fauces, larynx, pharynx, and esophagus are usually observed to be congested.

In the brain and spinal cord there is a general hyperemia and inflammatory foci, some hemorrhagic, others white and softening, which are said to resemble those found in poliomyelitis (Kaufmann). Leukocytes may accumulate at these foci until they resemble miliary abscesses. These changes are not uniformly distributed throughout the central nervous system, but affect certain structures more intensely. Of these, the medulla oblongata shows the most marked changes. Embryonic cells are found accumulated around the central canal and in the motor centers of the cord. When these embryonal cells accumulate around a cell the latter degenerates, and its space is occupied by the embryonal cells, constituting the embryonal tubercle.

Another finding is *Negri bodies*. Their nature is not known. Some (including Negri) have thought them to be the causative organisms of hydrophobia, others consider that they are encapsulated micro-organisms lying within the cells. They are constant and are found most abundantly in the horn of Ammon (pes hippocampi). Their discovery is the best and quickest method for microscopic diagnosis of rabies. These bodies appear only in this disease, remain throughout, and are not affected by processes of decomposition subsequent to death. The specimen should be procured from the cerebral cortex or pes hippocampi. They may be present at one site, while absent from another. They are found in large numbers in the cerebellum, and with less frequency in the medulla and the spinal cord and its ganglia.

RABIES IN THE DOG

Since dogs are the chief distributors of hydrophobia, it is necessary that as wide knowledge as possible of rabies in dogs should be distributed. The disease has been practically if, indeed, not entirely, as English physicians claim, eradicated from Great Britain by rigid methods of handling the dogs. The large cities of other countries—Vienna is an example—allow no dogs the freedom of the streets unless they wear muzzles. In all cases where rabies develops among the lower animals, especially among dogs in the cities, it should be compulsory to confine or muzzle all dogs until a satisfactory period elapses.

Symptoms.—The period of incubation in the dog varies from three to five weeks. During the onset the dog's nature changes and he becomes restless, excitable, and irritable. There is loss of appetite, a desire for indigestible material, such as sticks, grass, or earth, and the presence of these in the stomach with absence of food is a significant fact. Nausea may appear and dysphagia is present. The dog ceases to be playful and affectionate and is no longer obedient. He may be quiet or howl and bark at imaginary objects. I have known a hydrophobic bitch with young puppies to manifest the change first by whipping the puppies away and refusing to suckle them. This stage lasts from one to three days, and is the most dangerous one, owing to failure in recognizing the true condition.

The second stage, that of excitement or of raging madness, usually follows, although occasionally the second stage is wanting an the prodromal stage is followed directly by the paralytic. The do becomes utterly unable to control himself, runs about restless bites or snaps at everything that disturbs him, and may simpl snap at imaginary objects. He wanders aimlessly. Emaciatio is rapid. The frothing at the mouth, so deeply significant to th laity, is not constant, but inability to drink is marked, owing t pharyngeal spasms. Ropy saliva runs from the mouth on th account. The bark is hoarse and unnatural. This is followed i two or three days by evidences of paralysis, which begins in t hind legs and gradually ascends till death ensues, preceded by co vulsions.

When the paralytic stage follows the prodromal stage t symptoms just described may be wanting. The dog shows pa alysis of the muscles of mastication, indicated by dropping of t lower jaw, a sign accepted as pathognomonic by veterinarian and paralysis of the extremities and muscles of deglutition; th is more rapid in its course than those cases in which the stage excitement is present. This is known also as dumb rabies.

HYDROPHOBIA IN MAN

The period of incubation in man varies widely. The avera time is six weeks. The minimum period of incubation is abo two weeks and the maximum is one hundred and eighty day occasionally the disease has been reported to occur as late as o year or more, but, if this is possible, it is certainly very rare.

Prior to the onset of hydrophobia there may be certain pr monitory symptoms. The patient is uneasy and the scar m become reddened and itch or burn. If the wound has not heal the granulation tissue assumes an unhealthy appearance. Pa may be present in the scar or wound and in the region supplied b the same nerve. The local symptoms may antedate the disea several days.

Stages.—Three stages of hydrophobia are described—t premonitory, or first stage; the stage of excitement, or second stage; the paralytic, or third stage.

The Premonitory Stage.—This stage is characterized by the uneasy, restless condition, and the feeling of some impending evil. The patient feels and looks anxious; his disposition changes, and he is easily irritated or becomes melancholic. The sensorium is hypersusceptible to stimuli, as is shown by the presence of marked hyperesthesia. Photophobia may be present. The patient's attention cannot be concentrated, the mind wandering easily from the subject. Sleeplessness intervenes. Then the beginning spasms are indicated by disturbance of the pharyngeal and laryngeal muscles first. The patient cannot eat or drink satisfactorily; he strangles or chokes easily and has no appetite. The voice becomes husky and malaise comes apace. There is precordial distress. The mental symptoms become more intense and the individual continues to grow more and more unlike himself, until delusions and mania appear toward the end of this stage. At times disposed to talk excessively, at others he seeks solitude and silence. This stage continues for from eighteen to forty-eight hours.

The Stage of Excitement.—The symptoms gradually increase in severity and the spasms in extent, and the whole appearance becomes that of one gone mad. The face is wild looking and is pale. Irritation of the skin and stimulation of the auditory nerve causes dilatation of the pupils. The whole appearance is one of tension, the muscles are drawn and uneasy. The spasms of the first stage are increased in intensity, frequency, and ease of provocation. Every attempt to swallow either food or drink induces the spasm, and a sense of suffocation comes over the patient; dyspnea is present during the spasms; on account of the inability to swallow, the saliva accumulates and runs in strings from the mouth. Thirst is intense and insatiable from inability to swallow, the fluids attempted being forcibly spurted from the mouth. Vomiting is sometimes observed. The spasms gradually involve more of the voluntary muscles until they become general. They are usually described as clonic, but they may resemble those of tetanus, even the rather characteristic posture of opisthotonos being assumed. The sensorium becomes increasingly susceptible, and the least noise, especially that produced by splashing or running of water, the very sight or suggestion or thought of water or anything resembling it, the gentlest touch, the tiniest ray of light, will throw the patient into a convulsion. All normal reflexes are increased until the cortical centers of the brain become affected; the pupils remain dilated, normal reflexes disappear, and control of the vesical sphincters is lost. The length of the attacks increases, and they are relaxed by sheer exhaustion. The respiratory muscles are involved, and respiration, therefore, suspended until the spasm relaxes. On this account death may occur during this stage. The mental suffering is, from all appearances, as marked between the attacks as the physical is during their continuance. The dread of each succeeding attack, with its torturing pain and violent exercise of sore muscles, haunts the patient during the interval. He is lucid between attacks, unless the cerebrum is especially involved, when delirium occurs and persists.

The temperature changes are inconstant and unimportant. The temperature rises during the first stage and continues throughout the disease. Its range is from 100° to 105° F. As in tetanus, so here there may be a postmortem rise of temperature. The pulse is rapid and, with the approach of exhaustion, becomes very feeble and frequently irregular. Priapism, with its attendant discomforts, is usually observed, and desire for sexual intercourse may be marked and annoying. Unprovoked emissions sometimes occur.

The second stage lasts two or three days.

The Paralytic Stage.—A short while prior to death, usually less than one day, the spasms subside, the mental symptoms disappear, and the patient and his attendants are likely to consider him better and perhaps on the road to recovery. Not so; it is the beginning of the terminal, fatal, paralytic stage. The paralysis begins near the part bitten, and gradually, but rapidly, spreads till it becomes general, and, finally, on reaching the vital centers, death comes; unless, indeed, as is usually the case, death with or without coma comes from exhaustion.

The paralytic stage may follow the prodromal symptoms and no spasms occur. This is more likely to follow a large wound, or large doses of virus, and when the atrium is on the lower extremity. Paralysis usually begins in the region of the bite, but may start in the lower extremities as a paraplegia. The paralysis ascends rapidly, all muscles supplied by the cord are involved, and death supervenes when a vital center is reached. In this type swallowing is possible. The duration of the paralytic type is usually shorter than the raging (two to five days), but death may not occur before the seventh day.

Diagnosis.—Hydrophobia must be differentiated from tetanus, acute mania, hysteria, and lyssophobia or pseudophobia. The differentiation in any of these instances should, under ordinary circumstances, be made without difficulty if the history of the case and the symptoms be considered carefully. On the other hand, the need for such a differentiation is growing less frequent, owing to the preventive means employed. There are but a small percentage of physicians of the present day who have had the opportunity to study a case of hydrophobia in man.

A much more important study, therefore, is that enabling us to recognize hydrophobia in animals which have bitten an individual. The first fact to be remembered in such cases is that it is absolutely necessary that the dog (or cat) should not be killed after producing a bite unless an unmistakable diagnosis has been made, and in the vast majority of cases this is impossible at the time of the biting, owing to the greater frequency of such occurrence during the earlier stages of rabies. The animals should, therefore, be confined, preferably by a competent veterinarian, until the disease has had time to develop. If it fails to show positive symptoms of rabies within forty days the patient can be dismissed without preventive treatment. If the animal develops a disease, but recovers, this may be accepted as positive evidence that the disease is not rabies. The shorter period of incubation in the dog, and the fact that the disease must be practically beginning to develop before inoculation can occur, and, on the other hand, the long incubation period in man, renders it safe to wait for this information. If the animal is killed at the time of the bite, as is too often the case, then the animal should be turned over to a competent pathologist, or proper parts of the central nervous tissues should be placed in neutral glycerin and sent to the pathologist; it is immaterial if the animal has been dead long enough for decomposition to be well advanced, the Negri bodies can still be found. Fortunately, they appear early in the tissues and remain intact long after decomposition begins.

Prognosis.—The prognosis of hydrophobia is hopeless—no cases recover. However, the means of prevention are almost equally sure if the possibility of hydrophobia is recognized at the time of the bite. Just what percentage of individuals bitten by rabid dogs develop the disease is uncertain, but it is probably between 15 and 20 per cent. where no preventive treatment is used. It is higher in wounds of exposed surfaces, the hands, the face, and the bare legs, and lower in wounds of parts covered by clothing; higher in wounds produced by wolves and cats; higher in large lacerated or deep wounds; lower in superficial wounds and in abrasions. If preventive treatment is done by amputation the number of cases of hydrophobia is reduced ½ of 1 per cent.

Treatment.—*Prophylaxis.*—In all cases where bites have been made by suspicious animals, or where saliva from the mouths of such has come into contact with a wound or ulcer, as in those who permit dogs to lick their hands and faces, the wound and the surrounding area should be antisepticized either by the application of strong bichlorid of mercury solutions or carbolic acid, or by the application of the actual cautery, which is preferable. The longer the time intervening between the infliction of the bite and such treatment, the greater the probability of failure. If, however, su a method is employed early and thoroughly it can scarcely fail prevent the development of hydrophobia.

It is the rule now, and its application has almost abolish hydrophobia in intelligent communities, to recommend all perso bitten by rabid animals to take the Pasteur treatment. T inability of many patients to reach the laboratories, if distant, a to pay for the treatment, and the poor provisions of most citi for handling such cases, renders it often necessary to forego th treatment and to trust to antiseptic treatment.

Pasteur Treatment.—So far as has been learned from t many thousands of cases immunized by this plan, one may conclu that the treatment is absolutely devoid of risk of producing hydr phobia, unless those who develop the disease in spite of treatme are considered to receive their infection from this source.

The Pasteur treatment for prevention of hydrophobia in i dividuals who have been inoculated consists in the gradual ir munization by administering virus attenuated by drying, and each succeeding dose giving a less attenuated virus until the bo is immunized against the disease. The plan is very simple—t spinal cords of hydrophobic rabbits are dried, and the initial do is made from a cord that has been dried fourteen days, and th reduced to the lowest virulence, the second dose is given from o dried thirteen days, and so on until the last doses are made fro a fresh cord. The treatment is administered hypodermically, an emulsion in neutral glycerin. The following scheme will illu trate the plan of treatment:

Day of treatment..........	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of days cord was dried..................	14	13	12	11	10	9	8	7	6	5	4	3	2

If a sufficient number of days have elapsed before the beginni of treatment to demand haste alternate doses may be skipped, a only odd doses given, or a dose may be administered each morni and evening. Thus, the number of days of treatment may be r duced by half. It is important to state here that the emulsio employed for treatment may now be ordered directly from t manufacturer by the attending physician.

The treatment of hydrophobia, as such, has proved to be a frui less task. After the disease develops the Pasteur treatment is no more value than any other, and all that the physician in char can do is to control the spasm by quietude, darkness, antispa modics, anodynes, and anesthetics. Unlike tetanus, the disea kills independently of the spasms, and, even if they are controlle life is not prolonged by treatment.

CHAPTER XIII

ANTHRAX, WOOL-SORTERS' DISEASE, MALIGNANT PUSTULE, CHARBON

ANTHRAX is an acute infectious disease produced by the Bacillus anthracis, and appearing either as an external surgical lesion, or as an internal medical disease.

Etiology.—The cause of anthrax is the Bacillus anthracis, a widely distributed micro-organism, habitually forming spores which are very resistant to bactericidal agents, and pass unharmed through the stomach, although the bacteria are destroyed by the gastric juice. This bacterium was the first discovered of the large number of pathogenic germs. They are widely distributed, are found especially in soil and on the products of the soil. Once they gain a hold upon the soil they are with difficulty eradicated. In many regions endemic new territory is invaded by the blood and flesh of dead animals, or by contaminated water, such as the waste from tanneries flowing over the ground. From the soil, grass, and hay animals are infected, chiefly herbivora, occasionally carnivora; and from these animals and their products, flesh, blood, hides, hair, and wool, man becomes infected, often in parts of the world remote from the nativity of the animal. The most dangerous countries are the continent of Europe, South America, China, and South Africa; occasionally small outbreaks are seen in the United States. Hides, wool, and hair from these countries, especially from Russia and China, are the chief sources of the disease among workmen. Hence, those who work in tanneries, woolen mills, and manufacturers of hair products, butchers, and occasionally farmers, in districts where the disease is endemic, are infected.

Milk from infected animals may convey the disease. The external form may be contracted from any infected material, the internal more especially from materials which are dry and free from grease. Flies and fleas may communicate the infection.

The bacillus of anthrax retains its vitality indefinitely in the soil, and is not reduced in virulence or activity by the ordinary processes of manufacture, such as tanning. The mode by which anthrax infection produces disease is not known, no toxin having been discovered. It is antagonized by admixture of staphylococci and streptococci and destroyed by Bacillus pyocyaneus. When it is caused to grow at temperature above 42° C. it becomes attenuated, and has been used in this form for immunization of animals by injecting it in conjunction with an anti-anthrax serum. Pasteur's plan for attenuation of the bacteria for immunity was to cultivate the first injection twenty-four days and the second twelve days at the above temperature.

Pathology.—The morbid changes found in cases dying of anthrax are not of very great clinical interest. Hemorrhages into the viscera and ecchymoses of the serous surfaces, especially of the heart and lungs, occur. Cloudy swelling of the spleen and liver and enlargement of these organs is seen. The lymph-nodes are enlarged in the region affected, the bronchial nodes being especially affected. They contain a fibrinohemorrhagic exudate. There are effusions in the omentum and extraperitoneal tissue, and hydrothorax and effusion into the pericardium are frequent. The fluid may be serous or occasionally bloody.

The stomach and intestines may show inflamed masses, which break down and resemble the carbuncle of the external type of anthrax. In the pulmonary type the lungs become edematous and the alveoli fill up with a fibrinous exudate, which may be bloody and conform to the type either of lobar or lobular pneumonia.

The bacilli are recoverable from the blood in general infections, which occur more frequently from the internal than from the external type.

Soon after death the body becomes very dark and decomposition sets in early.

The External Type.—This manifests itself in the malignant pustule which occurs at the site of the atrium. The period of incubation is from one to three days. A local inflammation begins as a small livid speck, which rapidly enlarges and becomes red or yellowish. The lump may reach the maximum size of a hen's egg. Over its surface a bleb forms, which contains a clear watery fluid or a sanioserous fluid. This ruptures, the fluid escapes, and the inflamed central portion turns black, becomes necrotic, and from beneath it a discharge comes which contains the specific bacilli. The discharge is purulent only in cases of secondary pyogenic infection. The necrotic mass or scab seems to sink down so that a wall is left surrounding it. In the region immediately surrounding the pustule, either on normal skin or an infiltrated inflamed area, a number of ring-like vesicles form, and contain either a clear, bluish-red, or yellowish fluid. The lymphatics are occasionally involved. The malignant pustule is the most frequent type of anthrax in man, and usually appears, for obvious reasons, on the hands, forearms, or face.

At the beginning the patient complains of burning or itching at the site of infection; beyond this the pustule is and remains free from pain, but shows tenderness on pressure. As the case progresses the necrotic central mass increases in size, reaching sometimes the diameter of an inch. Edema appears around the pustule, and may extend to remote limits, affecting the whole head and neck or an entire extremity. The edematous surrounding area is hard and brawny.

The general symptoms produced by malignant pustule bear no definite relationship to the extent or intensity of the local lesion. They may be wanting entirely, they may appear in the first twenty-four hours, or only after a week or more. At first the constitutional symptoms are those of infection in general—malaise, headache, loss of appetite, perhaps nausea and vomiting, and rigor or chilliness. The temperature is variable and ordinarily of no significance. It may be high in mild, low in severe, cases of external anthrax. The pulse is accelerated and, as the patient grows worse, becomes irregular and weak. Symptoms of exhaustion appear as the disease advances; cyanosis and increased respiration occur, vomiting and diarrhea may be violent, and the stools are foul. The restlessness of the beginning may be succeeded by convulsions or delirium, and coma may develop, although the mind usually remains clear to the end, which may come gradually from exhaustion or suddenly and without warning. In the fatal cases death usually comes within a week, but in very severe cases it may come within thirty-six to forty-eight hours.

Anthrax Edema.—Occasionally anthrax manifests itself far differently from the lesion described above, showing as its chief characteristic an extensive, brawny, edematous swelling, the surface of which may show evidence of the underlying inflammation, and the condition may be confused with erysipelas. It is sometimes called anthrax erysipelas. The infection in an anthrax edema is not, as in malignant pustule, confined in the cutaneous tissue, but has been admitted into the connective tissue of the region attacked. The primary eschar is often wanting, and the edematous tissue has a translucent appearance. On incision into the tissues they appear to be filled with a more or less gelatinous substance, rather than with watery fluid of ordinary edema.

Blebs may form on the surface, and when they rupture are followed by the characteristic dry eschar. Anthrax edema is painless, but it is very rapid, and is much more fatal than malignant pustule. Anthrax edema is often associated with malignant pustule of the face. In this type, as in the preceding, the lymphatics, nodes, and vessels are affected, showing the usual changes of lymphangitis and lymphadenitis in extreme development.

General Infection.—The non-surgical forms of anthrax, known as internal anthrax, do not concern us here. They may be intestinal (mycosis intestinalis), pulmonary anthrax (wool-sorters' disease), or anthracemia. The symptoms of a violent infection develop, either with no previous warning or with the ordinary prodromal evidence of a beginning infection, and rapidly run their course to a fatal termination; at times death comes by collapse in two days or less from the beginning. In the pulmonary type the lungs are more prominently called to attention, and in the intestinal type gastro-intestinal symptoms predominate; but, while the involvement of these organs is respectively emphasized, yet the general condition is one of extreme intoxication and prostration. The temperature is rarely very high.

Diagnosis.—Anthrax can usually be recognized with little difficulty if it is thought of. The danger is that it will escape without diagnosis when only occasional sporadic cases are seen. In the external types the bacilli are easily discovered in the fluid of the blebs, but they are more difficult to find after the lapse of a week or after the occurrence of pyogenic infection. In malignant pustule the appearance of the primary lesion, with the central bleb and the surrounding zone of small vesicles on an inflamed base, and the subsequent formation of an eschar, is characteristic. In pulmonary anthrax the characteristic bacteria may be recovered from the sputum, and in mycosis intestinalis from the feces. The absence of pain in so violent an inflammatory lesion as external anthrax should cause search for the bacilli, as in the ordinary pyogenic infections of similar appearance, such as phlegmonous erysipelas and carbuncle, pain is a very prominent symptom. The occupation of individuals manifesting suspicious symptoms should always be inquired into specifically.

Complications.—When anthrax develops as a local or external process there is always danger of its becoming general, or of metastases, especially of the larger viscera, developing. When the lungs are affected, or when the edematous type occurs in the face or neck, edema of the glottis is likely to hasten the end.

Prognosis.—The outlook in all cases of anthrax is grave enough. In the internal forms the fatal cases may reach as high as 80 per cent. In external anthrax the prognosis is materially modified by the site of the primary lesion. Broadly speaking, the nearer the malignant pustule to the face, the greater the mortality; the mortality in these cases ranges from 20 to 30 per cent. Lesions on the neck and eyelids are the most dangerous. Those on the upper extremity have a mortality about half that of lesions on the face and neck, and those of the lower extremities about half that of the upper.

Those cases which show marked febrile reaction, or an active inflammation locally, are more favorable than those in which the reaction is slight. The quality and rate of the pulse is important. A moderate pulse-rate, with good volume, is favorable, while a weak, rapid, or irregular pulse is usually followed by death. Bell (quoted by Ravenel) says the pulse is the best guide.

Treatment.—*Prophylaxis.*—All animals dying of anthrax should be totally destroyed by burning. No part, such as the hides, should be used, for the danger of skinning the carcass is manifest. If cremation is impracticable, the body should be buried deeply, beyond the danger of vermin infecting the soil from it. The barns and stables which harbored the animal must be disinfected under skilled direction—it is a difficult procedure. The appearance of the disease in a herd of animals demands isolation of the diseased ones and immunization of the healthy ones by injection of serum. The rules of asepsis and isolation are to be executed rigidly by those in attendance upon anthrax patients, and subsequent sterilization of the apartments must be complete. Man has been successfully immunized by injecting serum.

Active Treatment.—The first principle to impress in the treatment of external anthrax is that the infection is much more uniformly limited to the local primary lesion in man than in animals, and that, therefore, nothing shall be done by way of treatment which can vitiate or reduce this natural protection. It has been shown that the plans formerly employed, of excision or cauterization, rendered the dislodgment of the bacteria from the malignant pustule much more probable than if no such interference had been made. Even so insignificant trauma as may be done by hypodermic injections or attempting to lift the eschar are interdicted. Second, the part affected must be protected from all other disturbances which may cause a spread of the infection; hence, all manipulation bruising, and unnecessary movement, active or passive, of the part is proscribed, and efficient immobilization is done by the application of splints and dressings. The part should then be placed in the elevated position. Antiseptic dressings may be employed, but they are probably of no value except to prevent secondary infection. Such dressings should either be applied and kept moist or used in the form of a salve, which prevents sticking of the dressings. The important points to remember are rest and absolute freedom from the slightest pressure or manipulation.

Serum Treatment.—In addition to its immunizing property the anti-anthrax serum has proved to be of great benefit in the treatment of anthrax in man. It should be used in all cases, whether external or internal, and should begin with large doses. The mortality is very materially reduced by its employment.

CHAPTER XIV

GLANDERS, FARCY, EQUINIA, MALLEUS

This is an infectious disease produced by Bacillus mallei, and characterized by the formation of pustules, abscesses, and ulcers.

Etiology.—The cause of glanders, the Bacillus mallei, is transmitted to man usually from the horse, ass, or occasionally other animals, and thus the disease occurs most frequently in those who care for or use these animals. The bacillus gains access to the tissues through wounds, ulcers, and rhagades; their ability to produce the disease consequent upon rubbing the bacteria into the skin has been demonstrated in experiments on animals. They may be recovered from the lesions, their discharges, or the blood.

Pathology.—The changes produced by the disease are not characteristic, and are those of a violent infection, so far as the viscera are concerned; the local changes conform to the type of lesion produced—inflammatory, pustular, or ulcerative—as the case may be, with now and then the appearance of gangrene. These changes are seen with greater frequency in the mucous membrane of the air-passages and in the lungs, or in the skin and subcutaneous tissue, although suppurative and inflammatory changes are often seen widely distributed throughout the body, especially in the muscles and joints, while any mucous surface may be attacked.

Symptoms.—There are two distinct types, dependent upon the anatomic site of infection and upon the spread from the primary focus. *Farcy* is the type which affects the skin and subcutaneous tissues, the external type. *Glanders*, the internal type, affects the mucous membrane of the nose, air-passages, and lungs. Either may be accompanied by the other or followed by it. Either may be acute or chronic. The acute forms of both farcy and glanders never become chronic, but the chronic form of either may at any time become acute.

The constitutional symptoms of the disease are dependent upon the absorption of toxins from the infected tissues, and not upon the presence of one type or another. Hence, a description of the general symptomatology may be given at once. The period of incubation is from three to five days. The local lesions may not show up until after the general symptoms appear, although the reverse is the rule. The patient may have a chill or chilliness, a rise of temperature which may be moderate or high at the beginning, headache, loss of appetite, weakness or prostration, and severe pains about the body, especially in the muscles, bones, and joints. These pains continue throughout the course of the disease. The pulse is quickened and becomes weak, and as the disease advances becomes rapid and perhaps irregular. Emaciation comes on rapidy in the acute cases; less rapidly, but no less surely, in the chronic. Nausea and vomiting may be present, and diarrhea is frequently seen, the stools being fetid. The mind may remain clear for an indefinite period, dependent upon the type of the disease; but, when the intoxication is intense and when exhaustion is marked, delirium and coma ensue, and a typhoid condition often develops. Death is often preceded by convulsions.

The urine contains albumin and possibly blood.

The temperature may be slight, but rises as the disease advances, reaching the highest point, 105° F., during the later stage of the acute types. The temperature shows distinct morning remissions.

Farcy.—Acute farcy appears as a result of cutaneous infection, although the atrium may have been so insignificant as to escape discovery. The beginning is manifested by the appearance of an unhealthy ulcer, which enlarges and discharges a bloody, serous fluid. The part becomes inflamed, swollen, and edematous, as if an erysipelas were present, and the lymphatics become enlarged. In about one week from the beginning of symptoms nodules appear in the muscles, and, in fact, widely distributed throughout the body; these appear as hard lumps; the skin over them becomes reddened and cyanotic, and after a time they rupture, discharging a bloody, gluey fluid, which, as a rule, does not resemble pus. In the skin over the abscesses blebs may form, and the whole inflamed mass may become necrotic and fall away. The ruptured abscesses are not disposed to heal, but remain as sluggish ulcers or sinuses, which continue to discharge their characteristic germ-laden secretion. The inflammation may also occur in the connective tissue and appear as a phlegmonous process. The joints become inflamed and swollen and suppurate. The constitutional symptoms grow worse as the local processes increase in number, and the patient rapidly becomes exhausted. During the course of the disease, from twenty to thirty days from the beginning, the body is covered more or less completely, particularly on the face and the extremities, with a pustular eruption, which may be discrete or confluent, and closely resembles the pustular eruption of small-pox, except for the manner of distribution and the failure of the pustules to umbilicate.

At any point in the course of acute farcy involvement of the mucous membranes of the air-passages and of the lungs (glanders) may supervene, increase the suffering, and hasten the end, which,

CHAPTER XIV

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without such complication, comes about six or eight weeks from the beginning.

Chronic farcy may begin more insidiously and slowly, and can often not be recognized until the disease is well developed; or it may begin with violent acute symptoms, which continue for a few days and gradually subside. In still other cases it begins with local evidence of wound infection, inflammation associated with involvement of the lymph-channels, and enlargement of the lymph-nodes. The constitutional symptoms are less intense and less rapid in their evolution, and in those cases where they precede the local manifestations may lead to various futile surmises as to their cause and fruitless efforts at relief. After a month or two (about the time death comes from acute farcy) the nodules and abscesses appear, but they are less active and less disposed to involve the adjacent tissues in the inflammatory process. These nodules give rise to little pain. Their behavior is the same as that of the abscesses of acute farcy, but they are very slow to rupture; remaining for months, they finally rupture and leave sinuses and ulcers, which, as a rule, persist, although exceptions are found in which healing is prompt and complete. The phlegmonous type of abscess ruptures earlier. These patients may seem to improve, and remain apparently free from disease for some time, and then another group of nodules form, and so on in succession indefinitely, with gradual loss of vitality and flesh. As the disease advances the former tendency for some of the ulcers to heal diminishes, and practically all ruptured abscesses remain as open sores.

The constitutional symptoms gradually assume the characteristic group already mentioned; the prostration increases, and the appearance becomes like that of advanced pulmonary tuberculosis, with chills and night-sweats.

Glanders.—The infection begins in the nose, and the same inflammatory, ulcerative, and suppurative lesions characterizing the disease elsewhere on the body are found in the nose. Pustules and abscesses are seen on the mucous membrane, and, when the soft tissues are destroyed, leave the bone or cartilage denuded or even perforated. These processes extend into the nose, pharynx, fauces, larynx and trachea, and into the accessory sinuses of the nose. There is an abundant discharge from the nostrils, of a mucous or mucopurulent, often bloody, fluid, which is tenacious and highly infectious.

The face, feet, and hands are swollen and indurated, and, after a few days, appear inflamed. The lymphatic involvement is marked. The lymph-channels are tender and so swollen that they are palpable. The pustular eruption, as described under acute farcy, then appears over the swollen and inflamed parts. Blebs, too, may form. The site of these pustules and blebs may become gangrenous, and, when the dead tissue separates, a discharge of the so-called pus occurs and the underlying anatomic structures are left exposed.

The constitutional symptoms are present, and grow worse with the advance of the disease.

The lungs become involved, in the form of a pneumonia, the patient develops a cough, which may be severe, and as the alveoli are occupied more and more the patient becomes dyspneic.

The pains in the bones and joints, and the widely distributed nodules with the usual behavior, appear just as in the other type.

This is the most rapid form of the disease, and terminates in death in a few weeks at most.

Chronic glanders is similar to the acute type, but different in intensity and rapidity. It usually comes as a sequence of chronic farcy. The nasal lesions are present, but are often so insignificant as to cause little discomfort and to escape the closest examination. There may be stuffiness of the nose, and more or less discomfort in the region of the nose and the frontal sinuses. The discharges may be abundant, as in the acute type, or almost entirely wanting.

The constitutional symptoms are identical in character with the description already given, but less marked. Cough is frequent and harassing. The ulcers are found in the same locations as in the acute type. The voice is unnatural. The lungs become involved, as is evidenced by the increased cough, expectoration, and dyspnea. If the pharynx is affected swallowing is painful.

Diagnosis.—Glanders and farcy doubtless often go unrecognized, owing to the obscurity of the symptoms or to the intrinsic difficulty many cases present to the diagnostician. The disease, when well developed and acute, presents great similarity to pyemia, for which it is probably frequently mistaken. The history of the patient's association with animals, particularly horses, is always important. The injection of mallein gives a reaction similar to that produced by hypodermic employment of old tuberculin in tuberculosis. It also produces a local reaction. The reaction establishes the presence of Bacillus mallei as the etiologic agent. The mallein test has proved its value beyond question in the lower animals, but its reliability for diagnosis in human infection remains *sub judice*. The most reliable laboratory test is the injection of the suspected discharge into the peritoneal cavity of male guinea-pigs. The testicles in these animals become swollen and inflamed, and suppurate in two or three days, as a rule, if the bacillus is present, and pure cultures may be obtained from these organs. Failure may result from death of the pigs from mixed infection.

The period of incubation is longer, three to five days, in glanders than in ordinary pyogenic infections. Microscopic examination may be necessary to clear up the diagnosis. When the atrium of infection cannot be discovered the disease may be confused with typhoid fever. However, the Widal reaction or cultures in ox-gall media will remove this source of confusion.

In the chronic types the appearance of the ulcers which cicatrize on one side and spread on the other (resembling the kidney-shaped ulcerating gumma), the denudation of bone, cartilage, tendons, etc., may lead to a suspicion of syphilis. Wasserman's reaction, the therapeutic test, and the history, together with collateral symptoms, should lead to a correct decision.

Small-pox may be suspected, yet the course of the two diseases is so different that discrimination should be easy. The fact that the pustules of small-pox umbilicate, while those of glanders do not differentiates them; the distribution of the eruption in the two diseases further separates them.

Prognosis.—The acute forms of glanders and farcy almost always terminate fatally. Death comes in acute glanders in one to six weeks, and in acute farcy after a slightly longer time. The chronic forms may continue indefinitely, and produce death by suddenly becoming acute or by exhaustion. Some 50 per cent. of the chronic cases recover, and this is more probable in farcy than in glanders.

Treatment.—The same rules of prophylaxis are to be followed here as in other severe infections. Everything that could possibly have been contaminated by the patient or the animal should be either destroyed or efficiently sterilized. The attendants must guard themselves cautiously against infection.

There is no treatment so far that influences the disease very markedly after it has once developed. If a wound is known to be contaminated, immediate destruction of the wound surface by actual cautery or escharotics will prevent infection. After the lapse of one hour such procedure is of questionable value. Amputation, if done early, has prevented general infection oftener than any other plan.

The treatment of local lesions, ulcers, abscesses, and sinuses must be rigorous. The abscesses are to be opened; the abscess cavities, the ulcers, and sinuses are then cleansed, perhaps curetted, and cauterized with the actual cautery, or swabbed out with a positive escharotic or active bactericide, as Harrington's solution or a solution of zinc chlorid. Lesions of the mucous membrane of the air-passages should be cleansed frequently by irrigation or by application of the solution on stick sponges, provided the lesions are accessible. The drugs recommended here are boric acid or potassium permanganate solutions, which may be more efficiently administered after cleansing with peroxid of hydrogen. Subsequently an antiseptic powder may be insufflated or blown into the nostrils.

The constitutional treatment is of little or no curative value. It is directed toward the needs of the case as they arise; tonic, stimulant, and nutritive measures are employed. Various drugs have been employed, the most favored among them being benzoate of soda, sulphur, and mercury by inunction. But these have little effect on chronic cases, probably none on acute. The employment of mallein has been ardently recommended. It is administered hypodermically in doses of 50 to 75 c.c. The benefit derived from the use of mallein is very doubtful.

CHAPTER XV

ACTINOMYCOSIS

Actinomycosis is a chronic disease produced by the ray-fungus, and characterized by the formation of granulomatous masses which break down and discharge pus from their sinuses, and by the progressive spread of the inflammatory process.

Etiology.—The classification of the cause of actinomycosis, the ray-fungus, has not been unanimously agreed upon. In fact, there are very diverse opinions as to its proper botanic position. The ray-fungus is a small mass, or colony, the size of which varies from the minutest visible, or even microscopic, mass up to $\frac{1}{16}$ inch in diameter. These masses are often kidney shaped. The mass consists of a central mass of filaments known as mycelia, and an outer mass of processes, which radiate in the form of minute clubs from the central mass. These clubs are not constant, and appear only in the older colonies; they are connected at their proximal ends with the central mass, the fibers of which extend into the clubs. The central mass is made up of two distinct parts, one encircling the other. The inner portion contains fewer filaments, which have no definite arrangement, but which extend through the surrounding layer at a single spot, and send their filaments out into the surrounding structures. The peripheral zone shows a more definite arrangement; the fibrils radiating from the surface of the inner part are germinal elements of the colony, and run in waving lines outward. These filaments branch and the terminal ends enlarge, constituting what are supposed to be spores. Either the spores or the fragments of the germinal layer may develop into new colonies. The ray-fungus is found in the soil and on soil products, as grains of wheat or barley, and on grass, straw, and the beards of small grain stalks. It usually affects the animals which feed upon such products, and is especially liable to affect cattle.

The ray-fungus is readily stained by a number of methods, may be cultivated on any culture-medium, although some of them grow it very indifferently, and may be readily recognized under the microscope, or, if the pus is examined soon after evacuation, the pale yellow colonies may be recognized by the naked eye. They are characteristic, but their absence does not warrant a negative diagnosis.

There are many varieties of ray-fungus, several of which do not affect mankind. The fungus is usually deposited in the tissues by hay, grain, or straw, but it is manifest that any substance carrying it may produce the disease by gaining entrance into the tissues. It sometimes originates in carious teeth. Because of the natural habits of the fungus, one may readily understand that animals are most frequently affected in the mouth and jaws (lumpy-jaw) or in the alimentary tract. Man acquires the disease by chewing grain, by picking the teeth with straws, or by placing any contaminated substance in the mouth. Occasionally wounds of the skin are affected.

Pathology.—When ray-fungus gains a footing in the tissues, which it often does with difficulty, judging from frequent failures of experimental inoculation, there appears a mass or nodule which closely resembles the growth of sarcoma. This mass is made up of granulation tissue, abundantly supplied with lymphoid and epithelioid cells and blood-vessels. Giant cells also appear in the mass, and may be abundant when certain organs, as the liver, kidneys, or heart, are affected. These masses may reach the size of an orange, sometimes they are even larger. The colonies are usually sulphur yellow, but may be white, brown, or green. In the midst of the mass the ray-fungus is found. After the nodules develop one of two changes occur. First, the granulation tissue may undergo fatty degeneration, break down into a puruloid fluid, and pro-

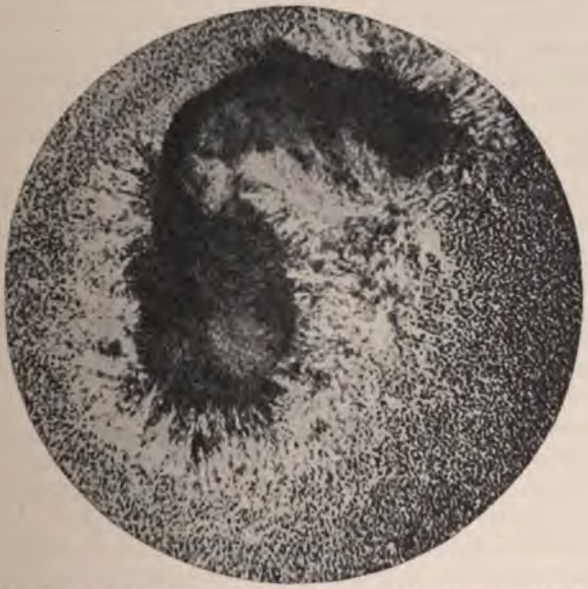


Fig. 43.—Actinomycosis of liver. Note the rays of the growth. (× about 150.)

duce abscesses (actinomycotic abscesses). The pus cavities are surrounded by granulation tissue or, when the process has continued for a long time, with new-formed connective tissue. Occasionally mucoid degeneration is found. The pus of these is glairy and tenacious, and contains the characteristic sago-like masses or colonies of ray-fungus and the broken-down cells of the mass. The second course pursued by the nodule is that, instead of breaking down, cicatricial tissue forms throughout, and, by contraction, causes shrinkage of the mass and retardation of its activity or sometimes complete cure. Calcification of the colonies may take place; if so, the fungi lose their vitality, and they then settle to the bottom of the fluid if it is allowed to stand a short while. When rupture has taken place the tissues surrounding the nodule are invaded, and as spreading continues on the periphery, breaking down continues next the abscess cavity and chronic sinuses are maintained, the nature and quantity of whose discharge is materially influenced by the presence of mixed infection. The cicatricial tissue, by its contraction, not only causes disfigurement, sometimes almost pathognomonic when affecting a skin surface, but also serious impairment of function in the viscera. Owing to this scar-tissue the tract of extension from the primary point of infection to the subsequent nodule may be discoverable, and this, too, becomes a valuable diagnostic point. The skin surface over the nodules remains unchanged until it is attacked, then it shows evidence of inflammatory changes, and is very similar in appearance to the skin covering a sarcoma.

The usual method of spread of actinomycosis is by direct extension. However, a general infection may take place when the ray-fungus extends into a blood-vessel and the enclosed clot disintegrates and enters the circulation.

Symptoms of Actinomycosis.—Actinomycosis is essentially a chronic condition, and there are few constitutional symptoms except such as grow necessarily out of a long-continued local inflammation, namely, exhaustion and emaciation. These conditions will not be found marked in the average case. In some cases fever is present, but it is usually due to secondary pyogenic infection. The lymph-nodes are not enlarged in unmixed infections. When a general metastatic infection occurs the course of the disease resembles septicemia and is fatal. When death comes it is due either to mixed infection or to exhaustion and amyloid change in important organs.

There are four types of actinomycosis usually described, although it must not be inferred that these are the only structures affected. The types are actinomycosis (*a*) of the jaws and mouth, (*b*) of the skin, (*c*) of the lungs, (*d*) of the alimentary tract.

Actinomycosis of the Jaws and Mouth.—This form of the disease is the most frequent, and comes, as already shown, from the habit of putting sticks and grain into the mouth, where an atrium is found in small wounds or abrasions of the mucous membrane and in carious teeth. There may be insignificant infiltration at the atrium, but the infection extends through the tissues and produces the nodules in the jaw, face, and neck, rarely in the tongue. An indurated cord is found, but not constantly, leading from the atrium in the mucous membrane, if infection occurred there, to the nodule. This cord is not found in other conditions. When the nodule ruptures, and surrounding structures are infiltrated and cicatrization takes place, great disfigurement occurs. When this happens in the neck the skin overlying the lesion is thrown into more or less transverse folds, an appearance rarely produced by other conditions. The muscles of the jaw become infiltrated and functionless, and the joint and surrounding structures are involved, so that the jaw becomes immovable. The cranial cavity is occasionally invaded, with sinister results. The pus from abscesses in the lower part of the neck may gravitate downward into the chest cavity or even into the abdomen. The cervical vertebræ and cord may become involved.

Actinomycosis of the Skin.—This type of actinomycosis usually appears secondary to one of the other forms, but is occasionally primary, gaining a footing in wounds involving the surface. It is found more frequently on the face and neck, but may occur on other parts. The primary sore often resembles syphilitic ulcers or lupus, and when affecting the foot and extending into the underlying bones it may resemble madura-foot. Nodules form in the region of the primary lesion, and gradually extend until the process may reach deeply into tissues and possibly surround the bone and give the impression that an osteomyelitis is present. A skiagraph should clear up the question. The nodules in actinomycosis of the skin run the same course as elsewhere, suppurating, softening, rupturing, and producing chronic sinuses and ulcers.

Actinomycosis of the Lungs.—Actinomycosis of the lungs may begin on the mucous membrane of the lungs or as bronchopneumonia. Any part of the lungs may be affected, but the lesions are most frequently found in the lower lobes. One or both lungs may be affected. The source of infection is through the mouth and nose, and is often secondary to actinomycosis of the nose. The foci develop, and may run either of the usual courses. In case abscesses form and rupture the discharge is coughed up, and contains the characteristic colonies; or, as is more common, the granulation masses are surrounded by dense connective tissue, the pleura is involved, and the lung adheres to the chest-wall. The stiff, hard, fibrous mass may occupy practically the whole of the lung, and the mass be occupied by suppurative foci and fistulæ scattered throughout. There is great tendency for the lesion to spread to the environs of the lung. The condition is difficult to differentiate from pulmonary tuberculosis for two reasons, namely, because the signs and symptoms are similar and both diseases respond to tuberculin tests. It is not uncommon to find the process extending from the lung to the chest-wall and rupturing on the cutaneous surface, rarely through the diaphragm into the liver or other abdominal organs.

Actinomycosis of the Alimentary Tract.—Actinomycosis of the alimentary tract may originate in any portion of the canal exceptionally; it occurs with far greatest frequency in the ileocecal region; therefore it may be easily confused with appendicitis, producing pain, tenderness, and fever resembling closely the symptoms of the latter disease. The course of the disease is in no way different from the usual, except as determined by anatomic conditions. Adhesions, nodules, suppuration, rupture into the hollow viscera or externally (the latter occurs more frequently than in the pyogenic processes), and the establishment of fecal fistulæ. Intraperitoneal rupture produces peritonitis. This type of actinomycosis is slow in development, and may remain obscure for a long time, or the abdomen may likely be opened for removal of the appendix.

Diagnosis.—The similarity between actinomycosis and sarcoma is very striking, and, up to the time when softening, rupture, and discharge of the characteristic pus occurs, it may be impossible to differentiate the two without recourse to a microscopic investigation. If an atrium can be found from which an indurated cord leads to the nodules, sarcoma can be eliminated. The presence of nodules may lead to the suspicion of gummata, and the appearance of chronic sinuses and enlargements in the region of the bones may confound this disease with syphilis or with osteomyelitis from other causes. Tubercle and syphilis may both have to be excluded; the former can be eliminated by inoculation and bacteriologic investigation, not by tuberculin reactions; the latter by Wassermann's reaction, by definite history of the disease, or by collateral symptoms.

When secondary infections occur, the pyogenic bacteria may dominate and give evidence of a more rapid, more acute condition than actinomyces would produce. General infection with ray-fungus resembles septicemia or pyemia.

Discovery of the ray-fungus is conclusive in all cases, but it must be remembered that under certain circumstances this evidence is difficult or impossible of demonstration.

Prognosis.—Actinomycosis is usually a chronic condition, except the pyemic form, in which the course runs more rapidly to a fatal termination. The more superficial lesions are more favorable than those of the lungs and intestines, but recovery in the mild cases cannot be expected in less than six to ten months. When the central nervous system or important viscera are invaded the prognosis is hopeless. A few pulmonary cases have been known to recover. The cause of death is usually exhaustion, emaciation, and amyloid degeneration.

Treatment.—The fact that actinomycosis is a localized infection in the majority of instances renders its treatment to a large degree surgical, provided the foci are accessible and can be removed without too great sacrifice of tissues. When the foci are in the lungs and in the intestines, the probability of benefit and the advisability of attempting surgical relief are much reduced, and, if the infection has already gained a wide hold on the structures, such efforts are rendered nugatory. After removal of the diseased tissues the wound is to be thoroughly disinfected with strong antiseptics, bichlorid, carbolic acid, or Harrington's solution. The abscesses may be incised, and all the granulation tissue cleaned out with a curet and the cavity packed with iodoform gauze, with or without the use of antiseptic irrigation; mixed infection must be prevented if possible. Bevan recommends copper sulphate given internally in pills, āā gr. $\frac{1}{4}$ t. i. d., and irrigation of the sinuses with a 1 per cent. aqueous solution of the same drug.

Aside from the internal administration of sulphate of copper, mentioned above, the general treatment, tonics, stimulants, and diet must be administered *pro re nata.* One drug stands out pre-eminently as the most satisfactory therapy, namely, potassium iodid.

CHAPTER XVI

TUBERCULOSIS

Tuberculosis is any lesion produced by the tubercle bacillus of Koch. The disease may affect any tissue in the body at any time of life, although the various types of the disease are more or less prevalent at rather indefinitely marked ages. The tissues affected and the complications arising determine more whether the condition is to be classified as a medical or a surgical one than the nature of the lesion, for fundamentally the lesions are identical. Tuberculosis is one of the very common diseases, so usual, indeed, that physicians accept many other conditions unquestionably as tubercular, without having gone to the pains of making an accurate diagnosis.

The question often arises as to whether a case of tuberculosis should be considered a surgical or a medical case. Many cases of tuberculosis that have been unquestionably surgical until recently, have, by recent advances in treatment, been handed back to the internist, who is able now to cope with them much more satisfactorily than the surgeon can. To-day there is scarcely a single type of uncomplicated tuberculosis that may be said to be always a surgical condition—*i. e.*, curable only by operation. It may be safely stated that every case of tuberculosis is a medical lesion prior to, during, and subsequent to surgical treatment, if the latter is at all necessary; that comparatively few cases are or should be surgical, and these are largely such because of failure of the patients to seek competent medical advice, or because of failure of the physician to recognize the true nature of the condition and to institute proper treatment. The field of treatment of tuberculosis by surgery is growing constantly more restricted, and the estimate of the value of necessary surgical treatment is assuming a much less important rôle than it once held. Hence, in giving the tubercular condition in detail in the following pages, while I have yielded to the older conceptions of surgical tuberculosis, I hope I have not failed to make plain when they are to be accepted as surgical lesions, and why they are not so frequently considered amenable only to operation.

Sources of Infection.—It is superfluous to discuss at length the sources of infection. The usual methods of contamination come from the nature of our food and social customs. Most cases of tuberculosis are traceable either to dairy supplies, meat supplies, or to individuals who have the disease. It is true that most children affected with the disease in any form are infected from milk (the disease is quite prevalent among dairy cattle, and they often show no evidence of it in a clinical way) or from a tuberculous inhabitant of the same house, frequently a parent or a nurse. The bacteria are, in the above manner, delivered to the individual daily, hourly, and it is incredible that one should escape infection when forced to live continuously under such an influence. Tuberculous patients often cough in the face of their friends or the physician, or attempt to come very near and speak directly at your nostrils during conversation, or are guilty of indiscriminate expectoration. It is superfluous, too, to say that the dust from houses occupied by people who have pulmonary tuberculosis or a discharging sinus or tuberculosis of the rectum, bladder, or kidneys is very likely to be polluted by the specific bacteria, and that food prepared by such, one type as well as another, is entirely untrustworthy, especially uncooked food or that handled by such an individual subsequent to cooking. The importance of association with tubercular patients is so great that the great insurance companies now refuse to insure one who has lived in the house with a case of tuberculosis until after the expiration of five years.

Atria of Infection.—Tuberculosis gains entrance to the tissues chiefly through the alimentary and the respiratory tracts, occasionally by direct infection of wounds. The bacteria are swallowed with food or drink, and pass into the lacteals with the food, are absorbed from the intestine, and pass thus to the lymph-nodes, where they gain a footing, or into the general circulation with the chyle, whence they are lodged at various points in the body; they find a more likely field for development in tissues that have recently been subjected to trauma or disease; hence, the frequency with which surgical tuberculosis is observed to originate soon after an injury, even though slight, or after an inflammation. They may find lodgment on the mucosa of the gut, and by direct extension through its wall attack the peritoneum. The most frequent source of tubercular peritonitis, especially in the male, is such an affection of the vermiform appendix. On the other hand, it is probably true that many more cases of tuberculous infection arise through the tonsils than by direct attack of the lungs. It is known that a great majority of "hypertrophied" tonsils and adenoids contain tubercle bacilli (some authorities claim as high as 75 per cent.), and that from such tonsils the lymph-nodes of the neck are next involved, and subsequently various near and remote organs. Carious teeth, too, may produce a similar course. The genital and urinary organs are likewise rather frequently affected with primary

tuberculosis; but it is probable that the bacteria are usually brough
through the circulation in most cases and lodged upon structure
already crippled by disease, most frequently gonorrhea. The tube
in women and the testicles and seminal vesicles in men are the mos
frequent sites of infection. In attempting to eliminate tubercl
bacilli from the blood the kidneys themselves become infected, an
from them the bacilli are transmitted to the bladder, which usuall
shows distinct evidence of involvement; and this, in cases of ren
tuberculosis, is worse around the ureter leading from the disease
kidney (both kidneys may be affected synchronously or at differen
times), and may be confined to the vicinity or be more or less widel
distributed over the mucosa. Or the kidneys may succeed i
throwing off the bacilli, and a primary infection may occur then i
the bladder.

Pathology (Kaufmann).—The fundamental and essenti
changes produced by tuberculosis are found in the tubercle.
tubercle is a mass of new-formed cells, epithelioid and giant, fi
connective-tissue fibrils, occasional lymphocytes, and tuberc
bacilli. It is of a grayish color and somewhat translucent. Th
tubercle is surrounded also by lymphocytes and occasional pol
morphonuclear leukocytes. The epithelioid and fibroblastic ce
and the giant cells are accepted as typical structures which cha
acterize the tubercle. However, in occasional instances, tuberc
show few or no cells of these types, but are made up of lymphocyt
and are spoken of as lymphoid or small-celled tubercles. T
derivation of tubercle from normal tissues occurs in the follow
manner: The bacilli are deposited in greater or smaller numbers a
liberate their poisons, which serve as an irritant and cause prolife
tive inflammatory reaction. The fixed connective-tissue cells a
the epithelial (endothelial) cells (if such be present) are incited
increased activity and multiply at an abnormal rate; a mass
cells the size, say, of a millet seed is formed, which is devoid
blood-vessels. The cells are larger than normal. The giant ce
are large and multinucleated, and the nuclei are situated at
periphery only, the result of an ineffectual attempt at multiplicati
the nuclei dividing and the protoplasm failing to divide on accou
of death of a great part of it; or they are due to fusion of t
endothelial cells. The connective-tissue fibrils of the tuberc
are partly the remains of broken-down normal connective tissu
partly new-formed tissue, and partly the processes of cells const
tuting the tubercle. The fewer and less virulent the bacilli t
sooner epithelioid and fibroblastic cells appear. The lymphocyte
occasional polymorphonuclear leukocytes, and fibrin come from th
surrounding blood-vessels as a result of the inflammation. Aft
the development of the tubercle it begins to undergo degenerati

into a finely granular, somewhat hyaline, caseous substance; this process commences in the center and extends toward the periphery.

Tubercle bacilli are found in varying numbers in the tubercle, living either between the cells or within the substance of the giant and epithelioid cells. In caseating portions the bacilli gradually disappear. Sometimes they are seen in heaps in the midst of caseous material.

The course of tubercles is variable. In the majority the tendency toward caseation is very apparent, but by no means all of them follow this course. In one instance a bit of fibrous tissue forms in the periphery of the tubercle, and encapsulates the central caseating portion and effects a cure, symptomatically at least. However, the bacilli enclosed in this capsule retain their vitality and are ready to return to activity when occasion is offered, as is shown by the readiness with which certain old healed tuberculous processes recur when the tissues containing their remains have been subjected to traumatism. Instead of the above course, the development of fibrous tissue may take place throughout the tubercle, before caseation has begun, and the whole mass is converted into a cicatrix, effecting a cure. Sometimes hyaline degeneration, both

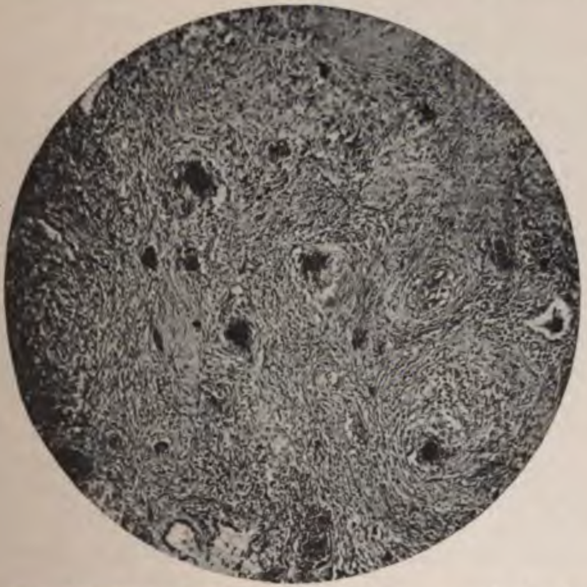


Fig. 44.—Fibroid phthisis. Tubercles in the lung surrounded by fibrous tissue. Note numerous giant cells. (× about 100.)

of the connective and the cellular tissue of the tubercle, takes place. In rare cases the caseated tubercular masses have lime salts deposited in them in varying quantities, so that the deposits appear in the form of small particles or occupy the whole affected structure. This is especially true of lymph-nodes. This process is not peculiar to tuberculous nodes, it sometimes occurs also in cancerous lymph-nodes.

When the behavior of the single tubercle is understood the general action of large areas of tuberculosis in the tissues becomes a simple process. If the tubercles form in large numbers and run their usual course, a considerable portion of tissue is destroyed and general and local symptoms compatible with such loss develop, due to the replacement of vital tissue by a devitalized and functionless mass and the absorption of large quantities of poison from the bacteria. If the process is on a surface, it is manifest that an ulcer forms when the breaking down occurs; if it involves an organ that may throw off the débris, such as the lung, the appearance of solidification followed by cavity formation, hemorrhage, and secondary infection is a necessary consequence, provided the usual changes occur. If the process is in closed spaces, such as bones, lymph-nodes, and the normal body cavities, then when caseation occurs the débris must accumulate, and, with the greater or smaller quantity of exudate plus the wreckage of destroyed tissues and the scattered

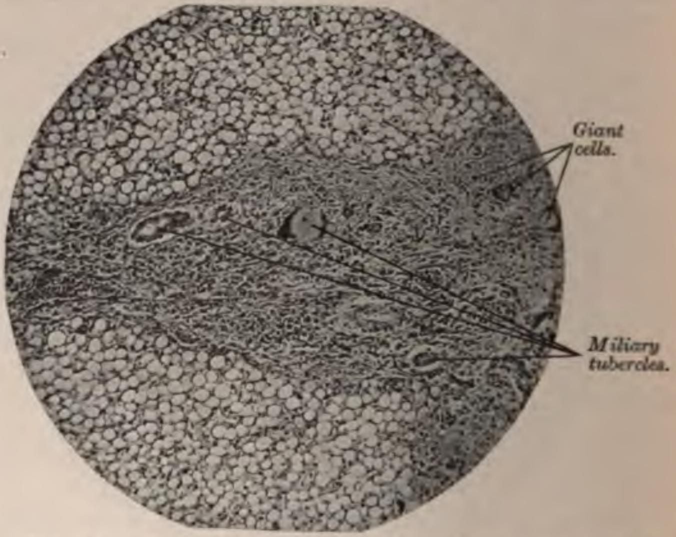


Fig. 45.—Tubercles. Section of liver showing fatty degeneration. (× about 100.)

bacilli, make up the puruloid material known as tubercular pus. In serous cavities tubercular infection may produce either a fibrous, serous, or puruloid exudate, dependent on the changes effected in the course of the evolution of the tubercles.

Tuberculous Abscess.—Inasmuch as various tubercular processes result in the development of the so-called tubercular or cold abscess, it is necessary to discuss this condition. Any accumulation of tubercular pus in an abnormal cavity is called a tubercular abscess. It is the common type of cold abscess, which simply indicates that no acute inflammation is present; it may have been always absent, or it may have been present and subsided. The accumulation of the fluid resulting from caseation and emulsion of the tubercular products either remains at the site of its formation, as is usually the case in acute abscesses, or escapes from this point and wanders along until anatomic or pathologic limits are reached, and a wandering or gravitative abscess is established, the most interesting form of which is the psoas abscess. Tubercular abscesses are occasionally subacute and rarely acute, or nearly so.

The most frequent sources of tubercular abscesses are infection of the lymph-nodes and the osseous system. Serous membranes, too, are frequent sources of tubercular pus, which accumulates in the form of an empyema. The deep fasciæ occasionally become infected with tubercle bacilli and cause tubercular abscesses.

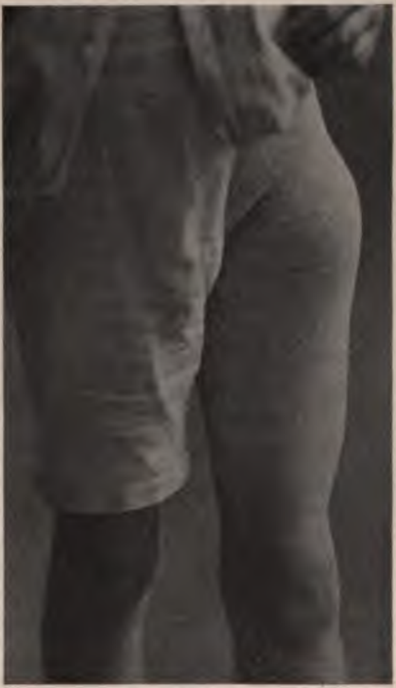


Fig. 46.—Tuberculous abscess of thigh.

The development of a tuberculous abscess may be rapid or slow, usually the latter. There is no history of an acute inflammatory process, but one of a tubercular infection, which is frequently so obscure as to fail of recognition until the abscess forms, or so insignificant as to escape the attention of even the patient. Pain, so prominent in acute suppurative processes, is wanting in most tubercular abscesses, except where the accumulation is great and discomfort is caused by the tension or dragging weight in large abscesses. Tenderness likewise is less marked. Discoloration over the surface of superficial tubercular abscesses may be present, more probably in the quickly forming ones, or, as is usual, it may be entirely wanting. When present it is confined to the surface over the abscess. Edema is absent. The abscess is, as a rule, not surrounded by an indurated zone of tissue, but is soft over the whole affected area alike. Pointing does not usually take place, but if the tension is great or if the abscess continues for a long time, pointing and even rupture may occur. The superficial contour of tubercular abscess is, as a rule, different from that of acute abscess; the latter usually is a more or less flattened elevation, with a higher, sharper apex at the place of pointing; the former, as a rule, tends more toward a spheric contour. Fluctuation is, of course, present, but the pus cannot be always so easily aspirated as in acute abscess, owing to the frequent presence of caseous lumps in tubercular pus. In acute abscess it is the rule that at one point the pus is considerably closer to the surface than elsewhere. Usually a tubercular abscess gives the impression to the palpating finger that the distance from surface to pus is uniform or nearly so.

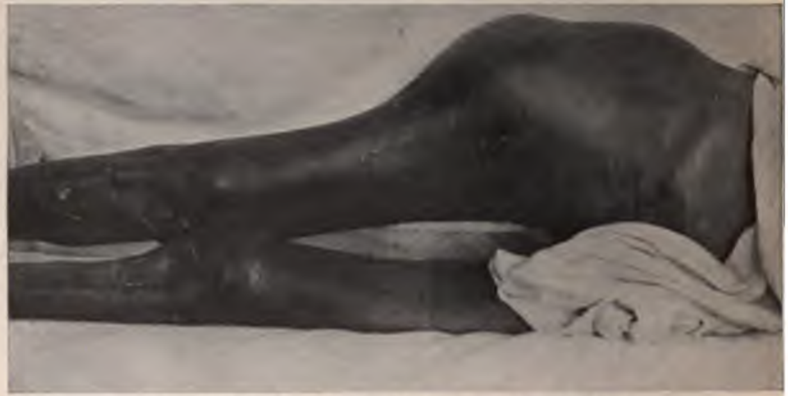


Fig. 47.—Tubercular (cold) abscess of right thigh.

Tubercular Lymph-nodes.—The usual avenues of infection of the lymph-nodes by tubercle bacilli is through the lymph-channels, which conduct the bacteria either from the atrium of infection or from an already established tubercular lesion. They are occasionally infected through the circulating blood. When a lymph-node infection occurs, the process may remain confined to the node or group of nodes attacked or spread indefinitely to other nodes in the course of the lymph-stream. However, retrograde infection is claimed occasionally to be produced when blockage of the usual channels occurs, and a reverse stream is thus brought about.

The changes produced within the lymph-nodes are of two types. In one there appear a number of miliary tubercles throughout the substance of the gland, which, on section, are visible to the naked eye; while in the other type, the so-called scrofulous lymphadenitis, there is a hyperplasia of the entire gland substance. They may reach an enormous size. The subsequent course of the second type is variable; in one case the gland more or less completely caseates and goes no further; if the caseation involves the whole gland, "the cut surface is dry, homogeneous, friable, fissured, or moist and yellowish white" (Kaufmann). The cervical, mesenteric, and bronchial nodes are usually affected. On the other hand, a second type may pursue a very different and much more favorable course, in which there is but little tendency to caseation or softening, but a continual increase in the hardness of the nodes. The nodes are sparsely infected with tubercle bacilli, run a very chronic course, and may reach the size of a turkey's egg. "The cut surface of these is homogeneous, glazed, pale, reddish gray, or brownish" (Kaufmann). The nodes of the neck, axilla, and groin are chiefly affected.

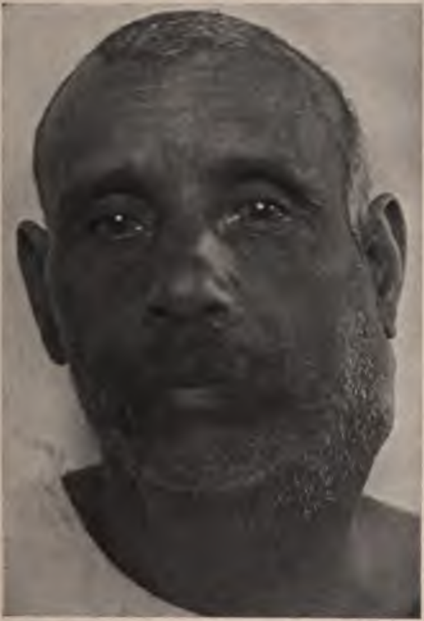


Fig. 48.—Tubercular lymph-nodes of neck.

Subsequent Course.—(1) Tubercular lymph-nodes may heal by destruction of the bacilli or by encysting them with new-formed fibrous tissue. (2) The inflammation may extend and affect the capsule of the gland and the surrounding tissue, forming a periadenitis. This fixes the nodes immovably, and, if more than a single node is involved, mats the whole group together into one immovable mass, in which frequently no longer evidence of the individual nodes is to be had in a clinical way. (3) Occasionally the lymph-node is relieved of the infection by calcification of the gland partially or completely. (4) A very frequent course is that so common to tubercle elsewhere, namely, caseation, softening, suppuration, and subsequent discharge of the contents to the surface through a sinus which may persist indefinitely if only a part of the mass is broken down at the time of rupture; for while the lesion is relieving itself through the sinus it may be extending at the periphery; so the sinus is maintained. There forms, too, in these cases a relatively great quantity of scar-tissue, which, by contracting, causes such disfigurement of the neck as scarcely will be found in any other condition except scars from burns. If burns can, therefore, be eliminated, these scars become almost diagnostic. Fortunately, they are less frequently seen than formerly. The sinuses from these as well as other tuberculous foci may heal temporarily, but they usually open at a subsequent time, owing to further progress of the process. If the rupture of a tubercular abscess takes place into a body cavity or into a vein a new local or a general infection takes place.

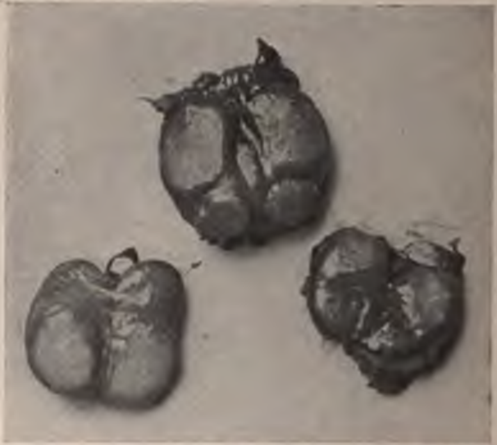


Fig. 49.—Gross section of tubercular lymph-nodes from neck.

Favorite Nodes.—It follows, from what has been said previously, that any lymph-node may be infected by tubercle bacilli. As a matter of fact, a few favorite sites embrace the vast majority of cases. The nodes of the neck, especially those of the anterior triangles, stand at the head of the list of the surgical cases. Possibly a greater number would show bronchial involvement. The intra-abdominal nodes, especially the mesenteric nodes, may be infected, particularly in children. The next group is the inguinal nodes and, perhaps somewhat less frequently, the axillary nodes. So that, from the standpoint of probabilities, one may be able to make a fairly correct, though still unreliable, estimate that if a certain group of nodes is involved it was or was not caused by tubercular infection. Occasionally the affection seems to be general. In tuberculosis of the lymph-nodes a single node may be involved or the whole chain; it may be unilateral or bilateral. The history of a preceding non-tubercular infection is no argument against tubercular secondary infection.

Diagnosis.—It is by no means easy always to recognize tuberculous lymph-nodes as such, except where they occur in conjunction with definite tuberculous processes in other tissues. The source of infection can often be detected, as, for instance, chronic enlargement of the tonsils or adenoids, which usually do not produce lymph-node enlargement unless they are tubercular. The groups of nodes usually affected by tuberculosis have been mentioned above, and they bear a very definite relation in most instances to sources of tubercular infection. On the contrary, syphilitic nodes, with the exception of those into which the primary lesion drains, show a distinct and unexplained predilection for certain groups, which, as a rule, are not very frequently affected by tubercle—*e. g.*, the posterior cervical chains, the epitrochlears, the popliteal, and the inguinal nodes. Syphilitic lymph-nodes are discrete, firm, movable, and, as a rule, not greatly enlarged or apt to soften or suppurate, and are painless; all these things may happen to tubercular nodes, with the addition that they often, if close to the surface, show redness of the skin.

Finally, the tuberculin and Wassermann reactions may be employed with a great degree of reliability as a differential plan between tubercular and syphilitic processes in general.

TUBERCULOSIS OF THE SEROUS CAVITIES

The serous surfaces of the body are, with varying frequency, all susceptible to tubercular infection. They embrace the pleura, the peritoneum, the true joints, and the meninges. They are affected in frequency in the order given.

The Pleuræ.—The pleural cavities are affected doubtless more often than any other serous cavities, often without being recognized, as a study of pleuræ in the postmortem rooms would lead us to believe; this is doubtless often interpreted as pleurodynia. Tubercular pleuritis may be primary, but it is usually observed as secondary to tuberculosis elsewhere, especially of the lungs, from which, by direct extension, it is an easy matter for the process to extend to the visceral pleura. It may arise in a similar manner from infected bones of the thorax or from the escape of a tubercular abscess into the pleural cavity. Tubercular pleuritis may manifest itself secondary to pulmonary tuberculosis which has produced neither sufficient physical signs nor symptoms to arouse suspicion.

The changes produced in the pleuræ by tubercular infection are manifold. First, large numbers of miliary tubercles may cover the pleura and produce an effusion. This is the rule in primary tuberculosis. The exudate may be serous, sanioserous, or serofibrinous. The pleura is covered with fibrinous exudate, and granulation tissue springs up which is abundantly supplied with vessels, and these are prone to bleed on the slightest provocation, thus giving rise to hemorrhagic fluids found in these cases. If there is a tuberculous cavity, about to rupture or already ruptured into the pleural sac, it will likely give rise to a suppurative pleuritis; in this pus both pyogenic bacteria and tubercle bacilli may be wanting. The presence of a purulent fluid in the pleura, with no bacteria, is almost unmistakable evidence of tubercular pleuritis. The fluid accumulating in tubercular pleurisy does not always have free access to the whole cavity, and in these instances requires care to avoid mistakes in diagnosis; the parietal and visceral pleuræ may adhere at a certain level, walling off a part of the pleural cavity, which may be filled with exudate. In all these cases there may be marked thickening of the pleura and the formation of nodes and bands of connective tissue, all of which contain large numbers of tubercles and are amenable to the laws governing the pathologic course of tubercles.

On the other hand, tubercular pleurisy may produce no free exudate, but remain dry and fibrinous. It is a productive inflammation. This fibrinous material organizes and causes dense adhesions between the opposing pleuræ, so that removal of the lung becomes an impossibility except by stripping the parietal pleura from the chest wall. These dense adhesions are especially frequent at the apices, although the base of the lung is often affected. It is most frequently seen in cases of pulmonary tuberculosis. Caseation of the masses of tubercles and new-formed tissue follow this type.

The development of tubercular pleurisy may be rapid or slow. The symptoms are less marked, as a rule, and the pain is less intense than in the ordinary non-tubercular types. At the same time the course of tubercular pleurisy is chronic and persistent. It may be bilateral in rare instances. When the effusion comes to the point of interfering with respiration and the heart's action it is usually easy to recognize its presence, especially if a history of tuberculosis has been suspected. It is not enough to recognize and to practice local treatment in these cases, their tubercular origin must be demonstrated if possible.

The Peritoneum.—Tubercular peritonitis originates from tuberculosis of the vermiform appendix. This is claimed to be the most frequent source in males; from the Fallopian tubes, the most frequent source in females; from the mucous membrane of the intestines by extension from a tuberculous ulcer through to the peritoneal coat, and from the mesenteric glands (tabes mesenterica), especially in children. It may be secondary to tuberculosis of other abdominal and pelvic organs, as the kidneys, adrenals, and bladder or seminal vesicles, and is rarely primary. Tubercular peritonitis is either localized or general, probably always localized at first when secondary to disease of a viscus, and general only when it is due to the rupture of some tuberculous focus into the cavity and the early diffusion of the discharge, or to the gradual extension of the disease from the first localized area. One sees, for instance, in tubercular peritonitis originating in the appendix numerous tubercles on the appendix and caput cæci, and as one leaves this focus the number gradually diminishes until no more are found.

Types.—There are, according to the usual methods of classification, three fairly distinct clinical types of tubercular peritonitis, although it is doubtful if one can claim that, from the pathologic standpoint, they are clearly enough separated from one another to justify a distinction. The *ascitic*, the *dry* or *adhesive*, and the *ulcerous* types are recognized, as well as a fourth rare type, *latent* tubercular peritonitis. This classification may be accepted as nominal, for many cases seen at operation or postmortem show indiscriminate mingling of the three types in a single abdomen, so that the classification cannot be accepted as a logical presentation of facts; it is rather a device to serve the purpose of teaching.

Ascitic Type.—The ascitic type is very similar to effusive tubercular pleurisy. The peritoneum is more or less thickly and widely covered with tubercles, and there is an accumulation of fluid in the peritoneal cavity, varying from an indistinguishable increase over normal all the way to the widest distention of the cavity. This fluid is serous or serosanguinolent. It has free access to the whole cavity in typic cases, but in the mixed cases may be encysted—*i. e.*, confined by adhesions to some definite part of the peritoneal sac. The condition must be distinguished from malignant intra-abdominal growths, from portal obstruction, and leakage of the chyle channels into the abdominal cavity.

Adhesive Type.—The adhesive type is very common. In this the intestines may be so bound together that they no longer appear to be intestines, the omentum and mesenteries are shortened, often almost to obliteration, the coils of intestine are bound together in an inseparable mass, and the normal surface appearances are all destroyed. It is impossible to lift such intestines from the cavity, or to separate them from one another without great risk of tearing

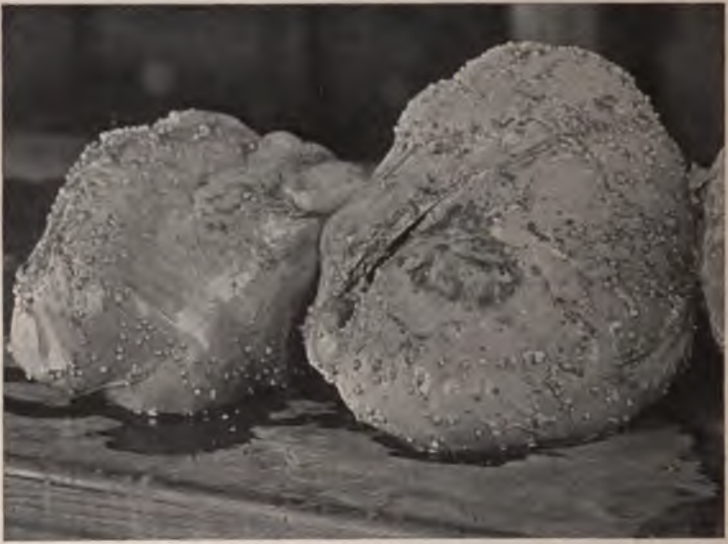


Fig. 50.—Tuberculosis of the visceral peritoneum.

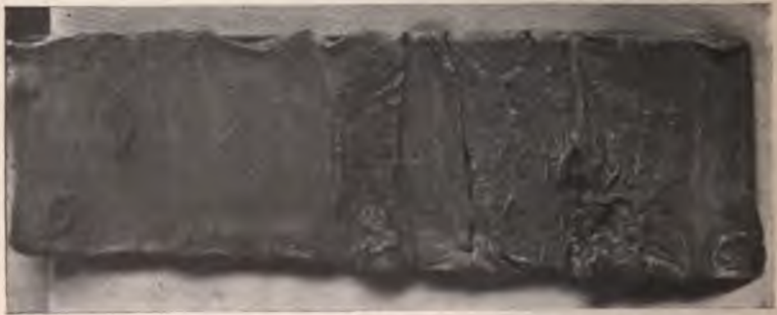


Fig. 51.—Tubercular ulceration of the mucous membrane of the small intestine.

into their lumina or destroying their blood-supply. In portions of the cavity not so far advanced the fibrinous exudate, yellowish in color, may be seen on the inflamed peritoneum. There is no free exudate; there is no peritoneum left to produce one; the process is obliterative; occasionally fluid is found walled off in pockets formed by the dense adhesions and may be serous or purulent. In the ascitic type the abdomen is large, in the adhesive type it is small, often scaphoid; in the ascitic type there are symptoms and signs of accumulated fluid; in the adhesive type these are wanting. In the ascitic type the patient is uncomfortable on account of weight and tension; in the adhesive, on account of interference with normal peristalsis, which may go to the point of chronic intestinal obstruction. In the ascitic type individual organs within the abdomen may not be palpated; in the adhesive, palpation of the distorted and displaced contents is easy, but recognition is impossible. The omentum may be felt lying along the transverse colon like a roll. In the adhesive type, in addition to the mass formed by contraction and matting of the normal structures together, there appear also at times great masses of tissues, which from the outside cannot be differentiated from tumors. They may attach to, or lie in, various structures, but are found especially in connection with the omentum and the uterine adnexa.

Ulcerative Type.—The ulcerative type is hardly worthy to be classed as a type; it is but an advanced stage which may develop in the adhesive type; when caseation and suppuration of the masses occur, there develop ulcers in the intestinal mucosa, sinuses leading from the caseated masses into the lumen of the gut, or to the skin surfaces, especially at the navel; redness, edema, and discharge of pus and feces from the navel are very important diagnostic signs that rarely occur except in tuberculous peritonitis. Fecal fistulæ, too, may be established elsewhere.

Latent Type.—The latent type needs to be mentioned, for it is not an unusual accidental finding during laporatomy when no suspicion of its presence had been aroused.

A moment's review of what has been said of the pathology of tuberculosis in general, and of the varieties of tubercular peritonitis, will force the conclusion upon the reader that fundamentally they are all the same, and that it is circumstances and stages of development of the reaction of the tissues that cause the variation. If the peritoneum is not destroyed, effusion occurs; if it is destroyed by plastic exudates organizing over its surface and then contracting, a second picture is produced. If caseation of these new products occurs and then suppuration—whether with or without secondary infection, is immaterial—and these products seek and find no outlet, the third picture follows logically upon the usual changes occurring in tuberculosis, and results from degeneration and disintegration of tissue.

Tuberculous Synovitis.—This group of serous surfaces, especially those of the knee and the hip, is often affected by tubercular infection. This must not be considered the sole source of tubercular joints (*vide* Tuberculosis of Bone and Cartilage). The lesion of the synovial membrane is similar to the remaining serous infections. Tubercles develop, the membrane becomes thickened, loses its luster, and appears moist, thick, and spongy. The thickened mass is called granulations. Caseating tubercles may be found; tubercle bacilli are scarce and difficult to find. There may be an exudate of clear serum, or it may be fibrinous, serofibrinous, or purulent. In the fluid often appear yellowish, elastic, small flattened bodies, known as rice bodies. The capsule of the joint may be little affected or completely destroyed by the process; invasion of the adjacent bones is possible. Organization of the fibrinous exudate may destroy the function of the joint. With the appearance of the inflammatory process the joint is more or less swollen, painful, and impaired in function or capable of motion through a very limited range. If effusion occurs the capsule is distended and fluctuant, and the joint is held involuntarily by the patient in such a position as to give the cavity the greatest capacity.

TUBERCULOSIS OF BONE AND CARTILAGE

Tuberculosis of bone is an exceedingly frequent surgical condition. The infection reaches the bone largely through the circulation of the blood. It affects spongy bone much more frequently than hard bone. It is, therefore, found usually in the small bones, such as the carpal and the tarsal bones, the vertebræ, and the cancellous extremities of the long bones. A favorite site for tuberculosis of bone in the young is the epiphyses of the long bones. This is especially interesting, as this is the chief source of tubercular arthritis. In this latter respect it is different from osteomyelitis produced by pyogenic bacteria, which usually attacks the diaphysis of the long bones. The infection is usually unilocular, but may be multilocular. The location of tubercle bacilli at definite sites is certainly favored by trauma, often so slight as to be forgotten, and some authors think that almost invariably some devitalizing process must be presupposed before such infection is possible. There are usually other tubercular lesions in the body, but they are not constant.

Having gained lodgment in bone the reaction of the tissues begins to manifest itself, either by the formation of tubercles or by the appearance of an osteomyelitic focus of granulation tissue, in the midst of which tubercles are found. Bacilli are very scarce in these lesions. This granulation tissue may infiltrate widely into the tissue surrounding the original focus. The fungoid mass of granulation tissue destroys the osseous tissue partially or completely. If partially, fragments of bone may be left in the mass in the form of bone sand. This is formed when the granulation tissue cannot absorb all the bone. If the granulation tissue grows in the lacunæ and absorbs their wall, and makes their spaces larger by making their walls thinner, and no suppuration occurs, the condition is known as dry caries (*caries sicca*). If caseation is marked and extensive (caseous tuberculous osteomyelitis) the absorptive power of the granulation tissue is at its lowest ebb, and gross specimens of bone are found dead *in situ*. These sequestra may show evidence of partial absorption by their irregular, pitted surface. They ultimately become completely separated from the living bone and lie in the midst of surrounding tuberculous granulations. The

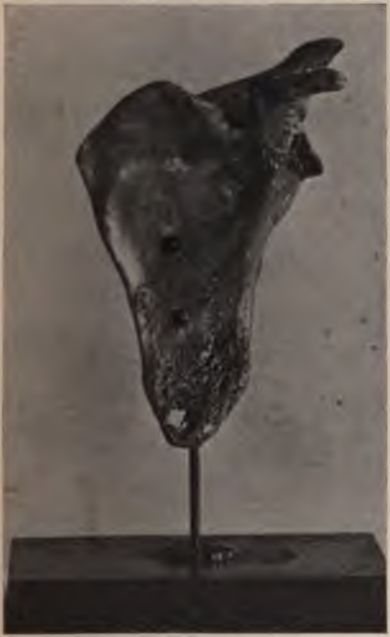


Fig. 52.—Caries of scapula.

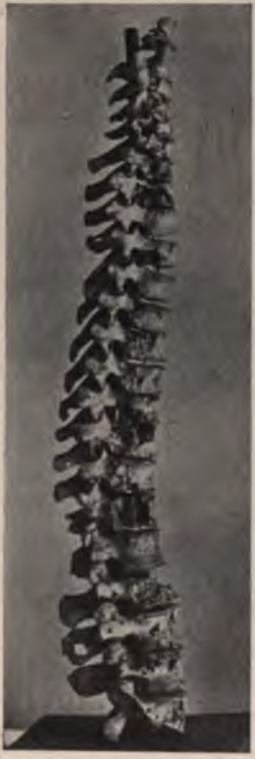


Fig. 53.—Caries of the spinal column, tubercular.

fungus type is seen usually in poorly nourished, emaciated individuals. Sometimes both types appear in the same case. The masses of tuberculous new tissue may remain unchanged and resemble tumor of the bone, especially sarcoma, or soften and suppurate, constituting a tuberculous bone abscess. The limiting wall of such an abscess is made up of tuberculous granulations, sometimes called abscess membrane (equivalent to "pyogenic membrane"). On the other hand, new fibrous tissue may develop around the pus and encapsulate it so as to produce at least a temporary cure. The subsidence of symptoms and apparent recovery does not signify that the bacteria are destroyed; they are simply latent, and not infrequently are rekindled into a new and often more violent activity by receipt of trauma at the site of the old focus.

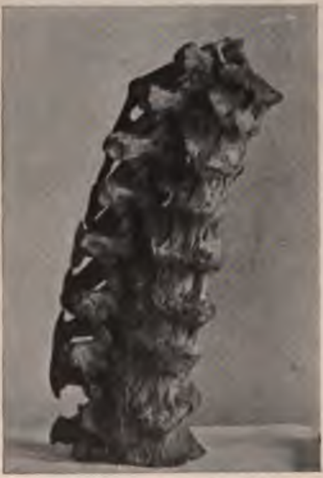


Fig. 54.—Ankylosis of vertebræ in a case recovering from tubercular caries.

Spina Ventosa.—Tuberculosis of the smaller bones, such as the phalanges, metacarpals, and metatarsals, as well as occasionally some of the larger long bones, for example, those of the upper extremity, develop a peculiarly interesting tubercular lesion known as *spina ventosa*. The internal parts of the bone are destroyed by absorption, thus increasing the size of the cavity, while the periosteum is building new bone at the surface. So there is formed a nodule, more or less spheric, hollow, and of considerably greater diameter than the original bone.

Pott's Disease.—Tuberculosis of the spine (Pott's disease) produces, where the bodies of the vertebræ are destroyed, or so softened as to be unequal to the weight they must support, very characteristic deformities. It is readily understood that the chief danger of such deformity lies in the damage done to the spinal cord.

The course of tuberculosis of bone is usually prolonged, and may last for many years. Pain is the most important symptom, and is, as a rule, not violent. An enlargement of the bone may take place at the site of infection, the location of which in cancellous bone causes suspicion of the presence of tuberculosis. The pus may escape and accumulate underneath the periosteum, or into the soft tissues surrounding the bone, and either in the vicinity of the bone lesion or remotely, after burrowing through more or less devious paths, form a cold abscess. So retropharyngeal abscess is formed from tubercular conditions of the cervical vertebræ and the bones forming the base of the skull, and psoas abscess from the dorsal and lumbar vertebræ. When tuberculosis of the bones of an extremity is sufficient to interfere with function, atrophy of the extremity takes place, and its circumference is then found to be less than that of the sound side.

When bone-sand forms in tubercular lesions, the pus coming through sinuses leading therefrom has a gritty, unctuous feel. The sinus itself has an abundance of scar-tissue in its wall, and the outlet of the sinus assumes a peculiar elevation above the level of the skin, which, if cut away, is re-formed by the unhealthy granulation. The mass of dead bone which has been necrotized is known as a *sequestrum*. The periosteum, if intact, builds an envelope of new bone around the sequestrum, which is called *involucrum*. The pus escapes through the openings in the involucrum, which are called *cloacæ*. The sinus leading from a diseased bone, especially if tubercular, is frequently seen to close or almost close, and give the impression that the process has subsided. It is unsafe to give too favorable a prognosis under these circumstances, however, for with insignificant, or with no provocation, the process is kindled again into activity.

The value of skiagraphy in the diagnosis of tuberculosis of bone is very great, especially when taken in conjunction with local and constitutional evidences.

X-ray evidences only show the variations in the density of bone, and cannot be accepted *per se* as signifying the cause of such variations. But if the symptoms, the shape of the light spots, and the location be considered, then a study of the skiagraph or of the part itself with the fluoroscope assumes very important diagnostic worth.

It must be stated plainly that a very grave mistake made by physicians is the assumption that all chronic bone lesions are tubercular, especially if there is marked swelling or a discharge. It is necessary always to consider especially typhoid bone lesions, actinomycosis, and tumors of bone; frequently, only after an exhaustion of clinical methods, the correct diagnosis can be made by incision and microscopic examination or by the employment of culture and inoculation tests.

Cartilage.—Cartilage may be attacked by tuberculosis which extends to it from some neighboring lesion. The poor resistance of cartilage renders it easily destroyed by tuberculosis. The chief affection of cartilage by this disease is in connection with tuberculosis of the joints, under which heading the course of the infection is given more fully.

TUBERCULOSIS OF JOINTS

This is a combination of tuberculosis of the synovial mem
and the articular cartilage, or of either independently. The
type has been studied already, in connection with tubercul
the serous membranes. We have left here, therefore, only to
tuberculous arthritis. The sources of joint tuberculosis are
the more common, or *osteopathic,* is seen in the young; the syn

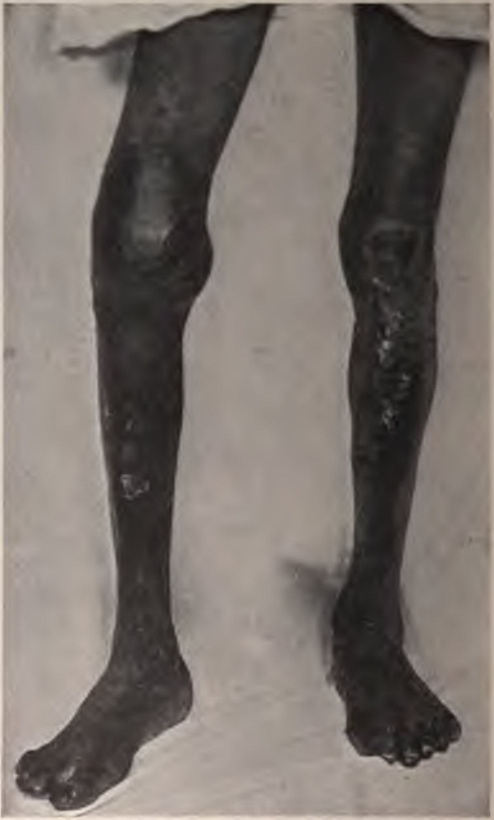


Fig. 55.—Tuberculosis of right knee.

or *arthropathic,* type is more common in adults. In either the
ultimate results may be produced. In the osteopathic ty
focus from which the joint is invaded is the epiphyseal cart
between which and the articular cartilage there lies a very thi
of bone. Tubercular epiphysitis, then, having developed,
but a short distance for the process to extend into the joint,
by chance it extends in a direction parallel to the joint surfa

attacks the peri-articular structures. Even when no invasion of the joint can be proved, the proximity of a focus of tuberculosis in an epiphysis may cause sufficient inflammatory reaction in the joint itself to produce a hydrops, which gives the joint the clinical appearance of having already become invaded with tubercle bacilli. This may continue a few days and then subside if no invasion occurs.

As the destructive process of tubercular epiphysitis approaches the joint, there forms on the articular surface of the cartilage a vascular membrane, pannus (similar to the pannus formed on the non-vascular cornea), which covers the surface more or less widely. Sufficient fibrous tissue and adhesions may thus be produced to protect the greater portion of the joint cavity from the infection; on the other hand, the pannus formation may fail to save the joint cavity.

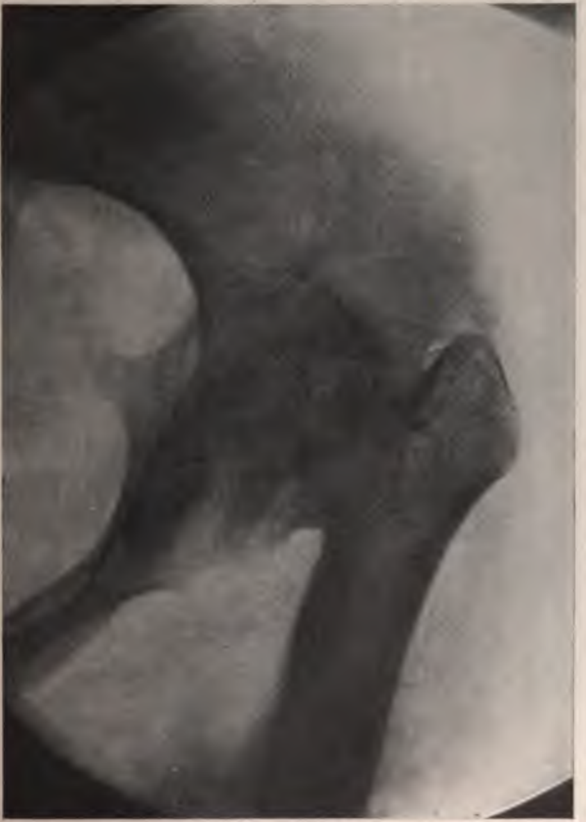


Fig. 56.—Tubercular hip-joint healed, with bony ankylosis.

The focus now perforates the cartilage and the contents of the lesion escape into the joint. As a consequence, one of three courses is followed. First, a diffuse tuberculosis of the joint occurs, and miliary tubercles develop over the synovial membrane, which, together with capsule and ligaments, becomes more or less infiltrated and sometimes disorganized into a gelatinous mass, and permits easy dislocation of the joint, or produces an unsteady joint, which is movable to an unnatural degree, and fills the joint cavity with a serous exudate. Second, an unusual quantity of granulation material may grow into and fill the joint producing the so-called fungus type. Third, the tuberculous masses may tend to caseate and break down into pus, which fills the joint and may escape through the capsule and form peri-articular abscesses. This unfavorable type is seen more frequently in the old.

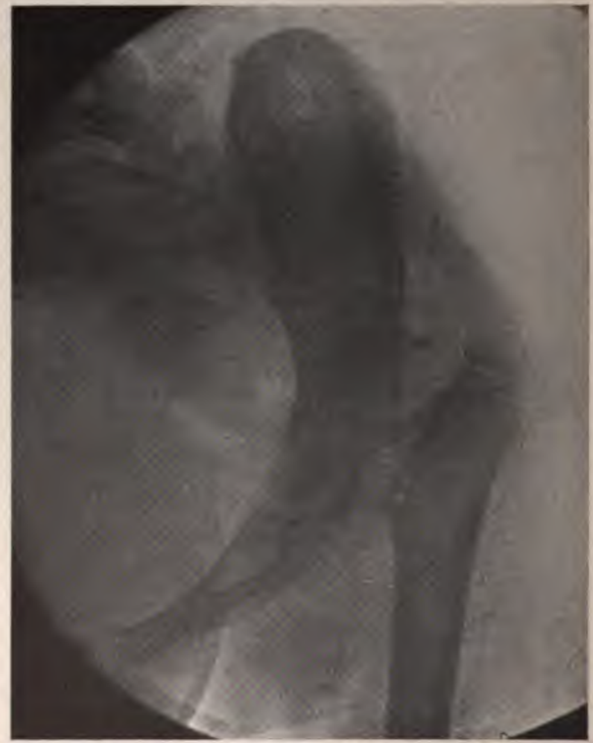


Fig. 57.—Tubercular hip-joint healed, with complete destruction of head and neck of femur.

As tubercular arthritis advances the cartilage softens, is replaced by fibrous tissue, which in turn is permeated with tubercles and breaks down, leaving the bone denuded of cartilage and subject to the ravages of continued spread or to ankylosis, if healing should occur.

It is, therefore, plain that in a case of tuberculosis of a joint, effusion, suppuration, adhesions, or ulceration may occur.

Caries Sicca.—Caries sicca is said to affect the cartilage of the joints, especially the upper end of the humerus. It shows no external signs of tuberculosis or of inflammation and is very chronic. The process destroys the cartilage and, in turn, is destroyed by the healing process, which firmly ankyloses the joint.

Signs and Symptoms of Joint Tuberculosis.—Pain, a very important symptom of joint tuberculosis, is always present, if not while the joint is at rest, certainly when function is undertaken or when extreme ranges of motion are attempted, either actively or passively. It is not usually so severe as in acute processes produced by pyogenic bacteria. Tenderness is usually present over the joint, and is frequently more easily elicited at certain points, especially when the capsule and the associated bursæ are affected. The joint is almost invariably swollen, and this may be due either to the new deposits, to fluid, or to both; and, in contrast with the atrophy of the extremity, involving even the bone in prolonged cases, gives the impression of an enormous swelling. If the ligaments of the joint are extensively degenerated a passive movement of the joint, especially in unnatural directions (as in lateral movement of the knee-joint), evinces the fact that the joint has become somewhat insecure. Fluctuation is discoverable in joints distended with fluid, but the pseudofluctuation of tuberculous tissues often leads one to conclude that fluid is present when the aspirating needle shows its absence. When denudation of cartilage occurs crepitus may be elicited on motion. The knee- and hip-joints are most frequently attacked and the tarsal and carpal joints, in the order named, owing to the great frequency of tubercular infection of the bones constituting these joints. More or less characteristic attitudes are assumed spontaneously when a joint is inflamed, and especially when there is a mass of fluid or tissue accumulated in the joint, and the attitude assumed is that productive of the least pain, namely, one that allows the greatest intracapsular volume and produces the lightest pressure. Tuberculosis of the joints is said to occur most likely in the healthy, active child, rather than the quieter, frailer child, owing to increased liability to injury.

FASCIA

The deep fascia may serve as a focus for tuberculous processes, which usually terminate by producing cold abscesses, and these, owing to their position and manner of development, may be easily mistaken for sarcomata.

KIDNEYS

The kidneys are frequently attacked by tuberculosis, usually secondarily to some other form of the disease, especially of the lungs, the alimentary tract, or bronchial lymph-nodes; it is rarely primary.

Miliary tuberculosis may attack the kidneys in connection with the general distribution of the infection, but they are of no practical surgical interest, as all such cases die, regardless of the plan of treatment.

The source of infection in tuberculosis of the kidneys is either the blood, in which cases the substance of the kidneys is affected, and in which extension of the infection to the remaining genito-urinary apparatus may occur, *descending urogenital tuberculosis;* or the form in which the other genito-urinary organs may become infected first and the kidneys secondarily, *ascending urogenital tuberculosis.*

The usual hematogenous form of renal tuberculosis is produced by the lodgment of bacilli in the capillaries and the formation of nodules, which, by disintegration of the caseous masses distributed through the kidney-tissue, form pockets of pus, which may remain separate from each other indefinitely and may communicate with the pelvis of the kidney, which thus becomes infected, and produces a tuberculous pyelonephritis. More rarely they rupture on the surface of the kidney. In this form the pelvis is partially involved at the beginning, and later on becomes more or less occupied with the tubercular products, and its limiting walls are ulcerated. The size of the cavities in the kidney continues to grow at the expense of the parenchyma.

In the ascending type, the pelvis is first affected and the surfaces of the papillæ ulcerate; then the process extends into the parenchyma of the kidney, which ultimately becomes completely occupied by the developing tubercles. They then pursue their destructive degenerative course and empty their contents into the pelvis. A tuberculous kidney may be very much enlarged throughout and show nodules over the surface, which are soft or hard, dependent upon the stage of degeneration reached. A rare form of the disease shows the formation of large nodular masses of tubercles which have no tendency toward softening.

In some cases of tuberculosis of the kidneys lesions are found extending widely through their substance, but showing little or no evidence on the surface of the organs.

A tuberculous kidney may be considerably enlarged, but this is not necessarily so; the disease may be unilateral or bilateral; when the latter, the stage of advancement is often unequal. If a single kidney is involved compensatory hypertrophy may take place in the other one.

The arteries supplying the kidney may become obstructed by tubercles and infarcts be produced. The process may attack the ureter on reaching the pelvis and thicken it until it becomes as large as one's finger, or so obstruct its lumen as to interfere with the passage of urine. Caseated foci may rupture into veins and produce general tuberculosis. The urine from patients suffering from renal tuberculosis usually contains pus and tubercle bacilli, which may be demonstrated by the microscope if they are abundant, or, if this fails, by inoculation.

Local Signs and Symptoms.—The first symptoms complained of are usually referable to the bladder—irritability, strangury, frequent urination. These symptoms appear without bladder involvement, but are intensified by this complication. There is usually enlargement and tenderness of one or both kidneys; tenderness is more especially notable over the diseased organ. Pain is present over the kidney; it is of a dull, heavy, aching character, and may be the first evidence of trouble. If the ureter becomes blocked, or when a mixed pyogenic infection causes the development of an abscess, the pain may become excruciating. The urine contains pus frequently and blood, occasionally in macroscopic quantity, frequently in microscopic quantity. The urine is acid. In the early stages of the hematogenous type there is no pus, for manifest reasons, but when softening and pus formation occurs, and the pus is discharged into the pelvis, it shows abundantly in the urine; as the quantity from a ruptured focus diminishes, the urine shows less and less of it until it perhaps disappears altogether; the rupture of another focus then causes an increase, and so on. This is the reason for the necessity of repeated examinations in some cases.

An important item in the recognition of tuberculosis of the kidneys is the remission of symptoms followed by a recurrence. During the remissions the patient feels much better, and may be devoid of local or constitutional symptoms; even the general condition may be much improved.

Cystoscopy often reveals a picture which indicates disease of one or both kidneys, in the form of an ulcerative or inflammatory zone, at or immediately surrounding the ureter of the diseased side. Further evidence is obtained by ureteral catheterization, from which may be learned the relative amounts and the physiologic and pathologic characteristics of urine from the two kidneys.

TUBERCULOSIS OF THE TESTICLES

The testicles are frequently tubercular, and in cases of pulmonary tuberculosis, when no discoverable lesion exists in the testicle, the bacilli may be discovered in the seminal vesicles or in the seminal tubules of the testicle, which shows how readily in such cases an inflammation or a trauma might kindle into activity tuberculosis of these glands. The epididymis is usually attacked at first, and the process here begins usually in the epithelium or the walls of the tubules, although it may originate in the connective tissue. The process may begin in the testis proper. Usually the condition is secondary to other tuberculous foci, but seems occasionally to be primary. When testicles, prostate, and seminal vesicles are all involved, the usual order of invasion is testicles first, then vas deferens, seminal vesicles, and prostate; on the contrary, tubercular epididymitis is rarely secondary to lesions in these structures. The nodule usually appears first in the head or the tail of the epididymis, and slowly and painlessly (or nearly so) enlarges, undergoing the changes already described for tubercle in general. The process may remain confined to the epididymis for a long time, or it may invade the body of the testicle. When this occurs several nodules may develop—rarely a uniform enlargement may occur—and produce considerable increase in the size of the organ, exceptionally up to the size of a goose's egg. The tunica vaginalis may be invaded and a moderate hydrocele develop, or the visceral and parietal layers may adhere and the scrotal tissue be invaded by the infection. Caseation and softening occur; if the process has approached the surface, the skin becomes reddened and rupture of the abscess takes place, establishing a chronic sinus, through which the degenerated substance of the mass and the destroyed testicular tissue is poured. On the other hand, the substance of the testicle may be completely destroyed and remain for a long time within the tunica albuginea. When sinuses develop, or where healing occurs, there remains a considerable quantity of fibrous tissue, constituting a deforming cord in the former, a nodule or group of nodules in the latter case. The vas deferens is often invaded and appears nodular or moniliform, like a string of beads in which the beads are rather far apart, a condition which, when present, is very characteristic; it is simulated by no other lesion of the spermatic cord. Later, the prostate and seminal vesicles may become involved and show no signs or symptoms. They may be discovered by palpation *per rectum*. Sufficiently frequent subsequent involvement of the second testicle is seen to impress the necessity of close attention to this condition. It may occur at widely varying intervals after the first lesion, and is always to be considered in treatment and in making a prognosis.

THE GENERAL SYMPTOMS OF SURGICAL TUBERCULOSIS

Tuberculosis, like other infections whose extent of involvement varies widely, will produce constitutional symptoms in proportion to the impression the toxins make on the general nutritional processes and the reaction called forth. In certain instances, where the infection is slight or of attenuated virulence, or where, by virtue of the anatomic structure or the pathologic change in the tissues, the rate of multiplication of the bacteria is inhibited and the absorption of poisons retarded, the symptoms are insignificant or wanting. The truthfulness of this statement may be illustrated easily by recalling that the majority of apparently healthy people have been at some time infected without having shown symptoms to call their attention to the structure, or to cause the physician to suspect the true condition under the most skilful examination. There are intermediate cases which produce clear symptoms of moderate degree and after a time recover; and, finally, cases which progressively, sometimes slowly, sometimes with astonishing rapidity, cause exhaustion, emaciation, and death. The constitutional condition cannot be said to be an accurate measure of the local danger, for a small focus may in one instance produce marked general symptoms, while an extensive lesion in another instance may call forth an insignificant reaction. This depends largely on secondary infections, the symptoms which may arise from destruction of the organ or tissue affected, and on accidents, such as hemorrhages or pressure of large new-formed masses on their environs.

The symptoms growing out of such interference with histologic structures or disturbance of function are accidental; those dependent upon the presence of tubercle bacilli in the tissues are essential, and, other things being equal, should appear wherever the focus of infection may be; they depend on the absorption of tubercular poisons. Patients who are suffering from a severe focus of tuberculosis are emaciated unless the condition is acute, and continued loss of flesh and strength without apparent cause should always lead to investigation for this source of trouble. Children who, in spite of proper nutrition and hygiene, fail to develop normally should cause suspicion of some latent focus, probably in the tonsils, adenoids, or the cervical lymph-nodes. Loss of strength is associated with loss of weight, and the patients often complain of shortness of breath and poor endurance on exercise. It is fortunate that in tubercular lesions local evidences have already indicated the presence of trouble, and perhaps its nature, before these general symptoms arise.

The temperature of tubercular patients may run a normal or nearly normal course until the disease has gained a firm hold. Usually, however, there is more or less disturbance of the temperature, which runs a diurnal intermittent course. There is a slight rise in the afternoon, usually 99½° to 101° F., but at times running much higher; while in the morning the temperature is subnormal, 97° to 98° F. This subnormal morning temperature is considered to be quite as characteristic as the evening rise. The higher degrees of temperature are due to violent or well-advanced infections, or to mixed infection, which is always responsible for the septic course observed in the advanced cases. The secondary infection is sometimes due to accidental causes, but in the majority of surgical cases it is doubtless due either to the accidental formation of sinuses or to unwise methods of interference on the part of the surgeon. In many cases of tubercular infection, such, for example, as tubercular peritonitis, the temperature is never observed to run high, and death comes as the result of gradual exhaustion of the physical resources.

There are general characteristics which cause the careful observer to think of tuberculosis, of which the long narrow chest, with an angle of less than 90° between the costal margins at the epigastrium, the pale, anemic appearance, the peculiar clubbed ends of the fingers, and curved talon-like nails, the pale, hard and soft palate, and the roughened pharynx, due to excessive adenoid tissue, usually associated with hypertrophied tonsils, are examples. These are suggestive; they cannot be accepted as diagnostic. If, in addition to these factors, there is a tuberculous heredity, a history of attendance upon or association with tubercular patients under ordinary unhygienic surroundings, or of abode in a house that is or has been inhabited by tubercular subjects, the evidence is more favorable for a positive diagnosis.

Tuberculin Tests.—The presence of tuberculosis in the body may be detected by the employment of one of the numerous tuberculin tests now in general use. They are not altogether reliable, but can be made to justify almost absolute conclusions when they are fully understood. All of them depend on either a local or a general reaction to tuberculin preparations. They react to actinomyces, and recently a series of reported cases would indicate that one of them at least (von Pirquet's) reacts to syphilis. Failure to obtain a frank reaction in tubercular cases may be due to the species of bacilli causing the disease. For example, avian or bovine infections in man respond but slightly, or not at all, to human tuberculin. The local tests, von Pirquet's, Calmette's, and Moro's, only indicate that tubercle bacilli are present somewhere in the body; they offer no clue to the site of infection. The rapidity and extent of the reaction indicates roughly the degree of intensity of the infection. The general reaction obtained by hypodermic administration of comparatively large doses of tuberculin likewise indicates the presence of, but not the part affected by, tuberculosis; however, if the suspected lesion is observed closely this method may be made to indicate both the presence and the site of the infection; for, when given in sufficient dosage, hypodermic administration of tuberculin will not only serve to increase the general symptomatology, but also renders the local tubercular condition more active; for instance, the tuberculous sinus may give out a greater discharge, and the tubercular joint may increase in size and become more painful.

PROGNOSIS OF TUBERCULOSIS

From a surgical standpoint the prognosis of tuberculosis is good, provided, as in those cases belonging to the internist, the condition has not been allowed to progress too far locally or to become general. There are few cases that offer no hope, unless they have reached a dire extremity. There is always danger, in surgical tuberculosis, of the disease becoming general, or of its attacking the lungs, the meninges, or some structure not amenable to surgical treatment, as happens when a second kidney is invaded. The prognosis is unfavorably altered when, by surgical interference or by accident, pyogenic bacteria gain access to a tuberculous focus which cannot be completely removed by surgical measures.

TREATMENT OF TUBERCULOSIS

Many of the tubercular processes which sometimes belong to urgery are coming to be more and more recognized as medical onditions. However, at present, it is deemed wise to lay down he fundamental principles governing the treatment of admitedly surgical cases, with this understanding, namely, that, as rule, when a tubercular lesion can be cured by other means ore frequently than by surgical it should not be operated on. urthermore, it may be laid down broadly that, while only a mited number of tuberculous processes are to be accepted as amenable to surgical treatment, all of them should be subjected to a rational medicinal, hygienic, and dietetic treatment before, during, and after the time they are under the surgeon's care. The proper selection of cases of tuberculosis for operative treatment presents often one of the most difficult problems the physician has to solve. The treatment of tuberculosis is then subdivided into general and operative.

General Treatment of Surgical Tuberculosis.—It has been too long accepted without question that cases of surgical tuberculosis were purely surgical cases. As the mode of action of bacteria, in whatever tissue they might lodge, has been more perfectly understood, and the possibility of extension, especially of tubercular bacteria, into other fields near or remote has been accepted as one of the great dangers of this disease, the necessity for more than local surgical treatment has impressed itself upon the minds of the profession, until now it may be stated broadly that general treatment of surgical tuberculosis is as necessary to consummate, as the surgical treatment is to initiate, a cure. Hence, the surgeon, if he will serve his patrons best, must either institute and direct such treatment, or turn them into competent medical hands who will direct a régime of treatment to be continued, often indefinitely, after recovery from his operative procedures. This general treatment consists in hygiene, diet, and the use of reconstructive tonic therapy and increase of the specific resistance of the patient, and can only be satisfactorily executed when the patient understands as fully as possible not only the nature of his malady, but the intention of the plan of treatment. The diet, hygiene, and general conduct of the patient, the employment of general tonic therapy, and the best plans for meeting complications are given in all standard works on the practice of medicine, and need not be repeated here. The specific treatment, however, I deem it wise to give here as bearing especially on the cure of surgical cases.

Specific Treatment.—The administration of tuberculin in various forms for the cure of tuberculosis, after passing through a prolonged heated discussion and repeated futile efforts to establish its therapeutic value, was practically given up as a forlorn hope for a long number of years, and has only recently been established upon a trustworthy footing. It is important, too, to mention the reason for failure in the beginning, namely, that it was administered in too large or too frequent doses. It is by virtue of competent use of tuberculin that so many cases of formerly surgical tuberculosis have been successfully treated without operation. In this way tuberculosis of the lymph-nodes, incipient renal tuberculosis, tuberculosis of the testicles, and of the joints especially, has been treated with very great satisfaction.

Tuberculin must be administered hypodermically, and should always be given by a competent physician, never by the patient himself, as is permitted sometimes, for not only is there constant danger of contaminating the stock from which the dose is taken, but accurate supervision of the effect produced on the patient and watchfulness for contra-indications must be had. Individuals who run a maximum daily temperature of more than 100° F. should either not receive this treatment until the temperature has been brought down under rest and proper diet, or should receive it only under the frequent observation and charting of temperature, pulse, and general symptoms. Any unfavorable symptoms resulting from the administration of tuberculin calls for its withdrawal if the dose is small or its reduction if large. It is unnecessary to make opsonic indices as a guide to this treatment; the clinical course is sufficient. The injection should not be made frequently at the same point, for the tissues will become inflamed and indurated and a small sterile abscess may develop at these places. Such abscesses need not be opened when found, as they will disappear in a few weeks if left alone. Their appearance is not a contra-indication to the continued use of tuberculin. Tuberculin is administered in doses varying from one ten-thousandth of one milligram to a maximum of one hundred milligrams. Few individuals, comparatively, are able to take the maximum dose, even when a gradual increase to the maximum has been made. But when the reaction indicates that a maximum has been reached, further increase in dosage should not be attempted, at any rate for several doses, and, if undertaken at all, it must be with the utmost vigilance. Overdosage produces the same symptoms and signs mentioned under the employment of tuberculin for diagnostic purposes. The interval between doses is four or five days. If the patient cannot come for treatment on the proper day, it is better to make the interval a day more rather than a day less. If for any reason the treatment is abandoned for a time and then renewed, the next in the series of doses should not be given, but a much smaller dose; if the interval has been very long, it is better to begin at the smallest dose. The rate of increase in dosage is important when the commercial tuberculins are used according to directions given with each bottle; the increase over the preceding dose varies all the way from 100 per cent. in the second dose from each phial to about 10 per cent. for the tenth dose. Therefore, physicians administering this remedy should not confine themselves to set instructions, but determine the amount of increase for themselves in each individual case.

It is impossible to know when a patient has taken tuberculin long enough, except by symptoms, signs, and laboratory findings. It is better, however, to continue its use too long than to stop too soon; and, after cessation, occasional observation of the general and local condition should be made to make sure that no recrudescence takes place.

Heliotherapy.—The latest advance made in the treatment of surgical tubercular lesions is by exposure to the sun's direct rays. It is claimed for this plan of treatment that it gives more satisfactory results than any or all of the methods previously employed, without the mutilating effects of surgery. The percentage of cures and improvements is higher than is seen under any other plan of treatment. The treatment is especially applicable to tuberculosis of bones and joints, and, it would seem, to other superficial forms of the disease. The few cases personally treated in accordance with this method have made marvelous improvement. The plan is simply to expose the naked structures to the sun's rays as long as possible each day. At the beginning the exposures should be for a brief period each morning and evening, with a gradual increase of time as tolerance is established. This plan is not to be considered the only valuable treatment, but it has proved of such unmistakable value as to demand its employment whether surgery is done or not. It is probably the most important aid the surgeon has discovered to hasten and insure complete recovery subsequent to operation.

Surgical Treatment.—The surgical treatment of tuberculosis may be subdivided into *operative, with removal of focus or organ containing it; operative, without removal of the focus,* and *non-operative.*

(1) It was formerly considered wise to largely sacrifice any tissue that had become tuberculous, and frequently the whole organ in which the disease appeared. This is partially true still. When the tissues have been destroyed, when caseation or suppuration has occurred, and when an extensive invasion has developed in a structure, it is best to remove the diseased tissue. If the structure of the part would be worthless after removal of the diseased tissue the organ itself is removed, provided its function can be satisfactorily replaced by another organ of the same or a different kind. Before, however, a nephrectomy, for example, is done it is extremely important to measure the capacity of the other kidney and to know its condition. In tuberculosis of bone, where large areas of bone tissue have necrosed, total or partial removal is imperative, and in certain instances an amputation or bone-grafting is necessary, owing to the loss of usefulness excision would entail. It is an excellent plan in tuberculosis of

structures that can be spared without detriment, and where there is reasonable assurance that the whole disease can be removed, to lose no time in waiting. This is especially true of tuberculous abscesses which have not been infected by secondary invasion. But, in order for this plan to be feasible, not only the abscess, but the focus at which the pus is produced, shall be accessible to such treatment. If such abscesses are not dealt with they may rupture, and the prognosis is seriously harmed by secondary infection. In those cases in which the primary lesion is removable, but from which other lesions have occurred secondary to it which are not amenable to surgery, the indication is to remove the primary lesion, and subsequently the secondary foci often become much more amenable to non-operative treatment. An instance of this kind is the removal of a tuberculous appendix or Fallopian tubes for the relief of tuberculous peritonitis originating in these structures, or the removal or resection of a tuberculous testicle after the seminal vesicles and prostate have been invaded.

In removing tuberculous bone-tissue it is wise to leave all the sound bone possible, and, if this cannot be done, the periosteum at least should be spared. The defect in the bone may be treated by packing it open with gauze, many surgeons prefering iodoform gauze, and allowing it to heal by second intention, or by filling the cavity with various substances. This plan of obliterating the cavity after removal of dead bone depends for its success on the absence or the removal of pyogenic infection. The cavity may be closed and allowed to fill with blood-clot, but this is likely to prove unsatisfactory in large cavities, owing to danger of incomplete organization. It may be filled with bone-chips or, better still, with decalcified bone-chips, made preferably from cancellous bone, or the cavity may be filled with a preparation of wax containing iodoform and hardening at a temperature above that of the body. If large portions of bone are removed the defect is most satisfactorily relieved by bone-grafting.

In tuberculosis of the joints, if the joint cavity is destroyed and recovery cannot occur without invasion of the joint, excision of the joint is done, and an attempt made to remove all disease extending into the osseous tissue and to approximate the bones for ankylosis in one instance, or to separate them and interpose some foreign substance as paraffin in some of the smaller joints, or, preferably, a dissected flap from adjacent tissues for the purpose of preventing ankylosis, as has been done by Murphy, by the interposition of flaps of fat between the cut bone surfaces.

When it becomes necessary to remove tuberculous lymph-nodes they are dissected out, preferably by the block method; it is impossible to clean them away thoroughly by enucleating one at a time. Tuberculous tonsils and adenoids should be enucleated completely.

Operation Without Removal of the Focus.—From what has already been said of tuberculosis it will be readily understood that many surgical tuberculous lesions are not susceptible to the ideal practice of complete, or even an advantageous partial, removal of the pathologic tissue. But many of these are to be benefited, often cured, by operative measures. In some instances operation is necessary purely for the comfort of the patient and to avoid interference with vital processes. Hence, effusion of serum or pus, as the case may be, if abundant must be drawn away by aspiration or incision in tuberculous pleurisy, peritonitis, or synovitis.

Tuberculosis of the peritoneum, unless too well advanced, is frequently cured by simply opening the abdomen. The chances of cure are materially increased if, at the same time, the primary focus can be determined and removed. It is necessary to bear in mind, however, that the intestines are very friable when infiltrated by a tuberculous infection, and hence do not hold sutures well, and that drainage of the cavity should be made only under imperative demands, for the crippled intestinal walls yield readily to traumata, and a fecal fistula that cannot be healed may be produced by the drainage material; in fact, as has already been mentioned, such fistulæ may develop in the course of the disease without outside assistance. How tuberculous peritonitis is benefited by laparotomy is not known. The ascitic type is the most amenable to this as well as other methods of treatment.

The most recent advance in the treatment of tubercular peritonitis is to paint the diseased peritoneal surfaces with tincture of iodin. This plan gives apparently much better results than simple laparotomy.

Tuberculosis of the pleura is treated by operation for relief of collateral symptoms when fluid accumulates. So long as the fluid is watery this treatment is satisfactory, and may be repeated *pro re nata.* If aspiration shows the fluid to be pus, then the treatment should be by the open method with drainage. The injection of formalin, 2 per cent. in glycerin, as recommended by Murphy, may be employed in either of these types after aspiration, and repeated until symptomatic cure results, but failure to produce a cure is frequent.

Tuberculosis of the joints is susceptible of the same methods of treatment as have been given under pleurisy. The joint may be simply aspirated; it may be aspirated and injected with 2 per cent. formalin in glycerin or 10 per cent. iodoform emulsion in glycerin;

immobilization is to be employed in conjunction. If these plans fail, and if the fluid is purulent, it may become necessary to open the joint and do such radical work as the pathology indicates.

Tuberculosis of the testicles has until recently been accepted as a positive indication for castration. Now castration is done when involvement of the testicle is extensive, and when the vas deferens shows nodules along its course, but if only a part of the testicle or epididymis is affected, resection of the diseased tissue under guidance of close inspection at the time may save the patient from further extension of the disease and from emasculation.

Tuberculous abscesses, which belong to the wandering or gravitative type, present a most difficult problem, and one fraught with great danger to the patient's life and great and often unending annoyance to the surgeon. The most important lesson to learn about them is that they should not be opened and drained, for this guarantees secondary infection, which multiplies the danger. Second, they should not be allowed to rupture of their own accord or even to approach too near the skin surface, for in the one instance they are sure to become infected with pyogenic bacteria, and in the other they are very likely to. If by means of rest, immobilization, and general treatment they can be prevented from further increase in size or encroachment upon a surface they should be left rigidly alone. If they continue to enlarge or to approach the surface, or if, by virtue of their location, they are interfering with some important function, or are likely to do so, they must be subjected to operative treatment. Aspiration has been often practised, but it offers all the dangers and few of the advantages of open incision. These abscesses should not be incised at their thinnest point, unless the tissues at that point are thick enough to allow firm suturing of the cut edges. The abscess cavity is cleaned out under the most rigid asepsis and the wound closed, preferably with two layers of sutures, covered with a dry dressing, and allowed to heal *per primam*, as it usually will. Beck's paste, formalin and glycerin, or iodoform and glycerin, may be left in the cavity if desired. The pus may reaccumulate and require repetition of the treatment a second or even a third time. If the line of suture breaks down the edges should be cut away and resutured.

Sinuses due to tuberculosis (including fistula in ano) are to be treated by injection of bismuth paste, and when this is absorbed or escapes the injection should be repeated. A large percentage of them are cured in this manner. The healing of localized tuberculous abscesses, such as ischiorectal abscesses, is more likely to occur without persistent sinuses if the paste is injected soon after incision.

Tuberculosis of the larynx has recently been reported as being amenable to cure by employment of the very simple operation of high tracheotomy.

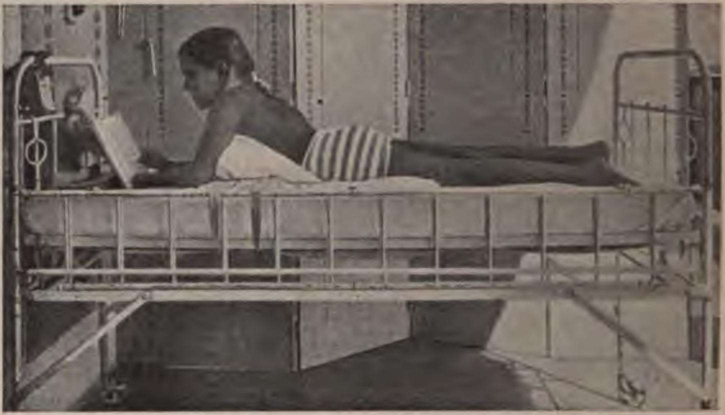


Fig. 58.—Illustrating position employed in conjunction with insolation in cases of Pott's disease (Straube).

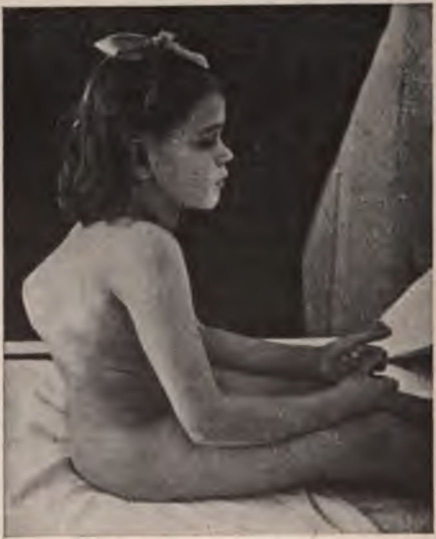


Fig. 59.—Case of Pott's disease prior to treatment by position and insolation (Straube).

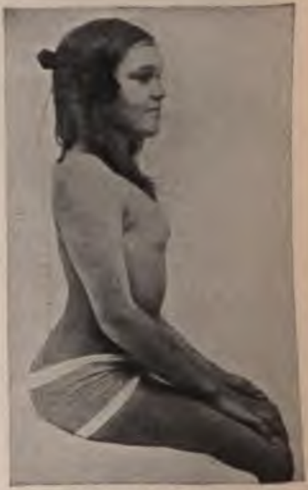


Fig. 60.—Same case restored by position and insolation (Straube).

Non-operative Plans.—The non-operative means for treatment of surgical tuberculosis are numerous, and embrace especially the methods recommended for the treatment of inflammatory processes in general. The most important in this connection are: (1) Rest, either by refraining from muscular exertion on the part of the patient, or enforced by the application of such apparatus as splints, braces, or casts. If possible, it is best to prevent movement of the affected part without completely depriving the patient of the privilege of exercise and out-door life. (2) Position is important in those cases which are immobilized, and should be such that the patient's comfort may be least disturbed, and the permanent deformity, if deformity must come, may be as much as possible compatible with useful function. (3) Bier's hyperemic treatment finds, perhaps, its most serviceable field in surgical tuberculosis, and is produced usually by the passive methods. (4) Massage is of especial value, and is to be applied not only to the diseased part, but to those structures whose nutrition is interfered with by loss of function. In cases of sinuses dependent on tuberculous processes the application of Bier's method by employment of tourniquets, or by cupping over the mouth of the sinus and the injection of Beck's paste, or the employment of the latter plan alone, gives most satisfactory results, and should be undertaken in all such cases before resorting to more active methods unless the indication is very positive against it.

CHAPTER XVII

SYPHILIS

This disease is one of such varied clinical manifestation that it would be beyond the present purpose to discuss it even to a moderate extent. The subject will, therefore, be discussed only to such an extent as its relation to surgery and its differentiation from other surgical lesions demands.

Etiology.—The cause of syphilis is the Spirochæta pallida, discovered by Schaudinn in 1905. This minute attenuated spirillum is discoverable in the juices of syphilitic tissues, whether the lesion is primary, secondary, or tertiary, abundantly usually in the former two, and with difficulty in the last. The spirochete is transmitted by mediate or immediate contact, usually the latter, and that during the sexual act, which is the sole reason for syphilis being considered a venereal disease. Mediate infections and those produced by other than sexual contact are not infrequent, and physicians suffer more from infection by this means, especially from needle punctures, cuts, and abrasions, than any other class. There must be an abrasion of the mucous or cutaneous epithelium before it is possible for infection to occur.

Pathology.—The essential lesion of syphilis is an exudative and proliferative inflammation. While the disease is capable of unlimited manifestations, and may simulate a vast number of pathologic and clinical conditions, the fundamental fact must not be lost sight of that an infection producing an inflammatory reaction is the essential underlying factor. Various accidents and complications may befall these syphilitic lesions, dependent somewhat upon the site of their formation; thus, ulceration, caseation, sclerosis, caries, necrosis, and desquamation of epithelium may occur and secondary infections may take place. In the earlier stages of syphilis the tegumentary structures and lymph-nodes are chiefly affected, but, as the disease passes into the so-called tertiary stage, there is no structure in the normal body, from the nails to the central nervous system, secure against its ravages.

The period of incubation varies from fourteen to forty days, and during this time the patient shows no signs of infection. The abrasion which served as the atrium heals frequently without being discovered; it may become infected with ordinary pyogenic bacteria and soon heal, or it becomes infected with chancroidal bacteria, and develops immediately into a chancroid which may obscure all signs of a beginning syphilis.

The Stages of Syphilis.—The course of syphilis must be recognized as a continuous one, except as it may be interrupted by the administration of antisyphilitic remedies. Three stages are usually recognized and described, although any or all of them may fail to appear or escape recognition; and it is precisely these cases running an atypic course that have caused the chief difficulties in the diagnosis of late syphilitic lesions, which especially concern the surgeon. The history of a definite typic course of the disease is of very positive value; its absence has no significance in the presence of questionable late manifestation.

Primary Stage.—The primary stage of syphilis extends from the first appearance of the chancre to the general eruption, which may be looked for at an average of six weeks from the date of the chancre, but varies from two to three weeks, or, in rare cases, even to six months. This is known as the period of secondary incubation. The primary stage is essentially the stage of the local sore and the lymphatic involvement attendant upon it. This lymphatic enlargement is always in a correlated group of lymph-nodes. A single node may enlarge; a single large one and several smaller ones may be observed, or several nodes of about the same size may be seen. They are painless if due to pure infection, firm, discrete, non-adherent, and do not suppurate.

The chancre may be obscured by mixed infection so as to present no characteristic signs, or may be so typic as to leave little or no room for a mistaken interpretation. It is almost invariably single, but there may rarely be more than one primary sore, due to simultaneous infection of more than one atrium. The chancre is by no means constantly an ulcer, although ulceration is the rule. The characteristic feature is induration. The lesion may begin as a slight abrasion which heals and breaks down again, or never heals, or it may not be possible to recognize that an abrasion has been present at all, and the first evidence may be a watery blister. Induration may be felt in all typic chancres, and appears either as a roundish lump or as a flattened, nummulated disk, the thickness of which varies downward to that of a sheet of paper, and gives to the palpating fingers the impression of something having been deposited under the upper layers of the skin. Chancres are painless, do not discharge abundantly when they ulcerate, and may become slowly larger and stubbornly refuse to alter their size, or gradually fade away. The indurated papular chancre is very rare, and shows no break in the epithelium; the ulcerative chancre is next in frequence, and involves a part or all of the thickness of the skin; it has sloping edges, and the raw b may be partially or completely covered with a grayish, adher pseudomembrane. The erosive type is the most common, an characterized by exfoliation of the epidermis, which leave glistening surface on which the pseudomembrane may app and surrounded by a cyanotic or red areola. The discharge f the last two types named is serous or sanioserous. The sha chancres in general is approximately round. Chancres do respond to any local non-syphilitic treatment.

Second Stage.—The second stage of syphilis begins with manifestation of constitutional infection, and is character by the appearance of general lesions distributed over the b situated superficially, for the most part involving especially skin, the mucous membrane and lymph-nodes, and symm It is the eruptive stage or stage of constitutional involvem and prior to the recent discovery of positive diagnostic met it was waited for and accepted as the pathognomonic sign a primary sore was truly of a syphilitic nature. The duratio the secondary stage is not nearly so well marked as that of primary, for while the appearance of a syphilitic eruption m definitely the end of the first stage, only its appearance failure to reappear indicate the end of the second stage. generally accepted that the second stage lasts for from six mo to two years or longer. This stage of syphilis may fail enti to appear or may be obscured by the inadvertent use of cury during the first stage; however, its development no lo figures extensively in the diagnosis of syphilis, and it is now in tionally prevented, as it often proves of great embarrassmen the patient, and there is no longer necessity to lose valuable in treatment by permitting the disease to continue unmoleste several months.

The eruption of syphilis usually appears after the ge lymph-node involvement, but occasionally precedes it. The and mucous membrane eruptions are called syphilids and ass various symmetric manifestations. They are produced in upper layers of the skin and mucous membrane, and appea hyperemic, more or less indurated and infiltrated spots, di pear during the course of the disease or under administratio treatment, and leave the skin normal. The later secon syphilids may involve the deeper layers of the tegumen membranes and cause destruction of tissue, followed by cicat tion. The eruption of syphilis may resemble or simulate of certain eruptive fevers and skin diseases so closely th differentiation cannot be made from this source. They, as a require several days to mature, but occasionally appear and di pear with such rapidity as to escape the patient's observation. Like the chancre, they usually produce no subjective symptoms. There is a tendency for secondary (early) syphilids to assume a roundish shape and for groups of them to appear in circular arrangement and symmetrically. The color of the eruption is important, red at first, and later assuming the so-called copper color. The color disappears on pressure and returns on its release, as in all hyperemic conditions. The epidermis over the surface of the syphilids scales. It is important, from a diagnostic stand-

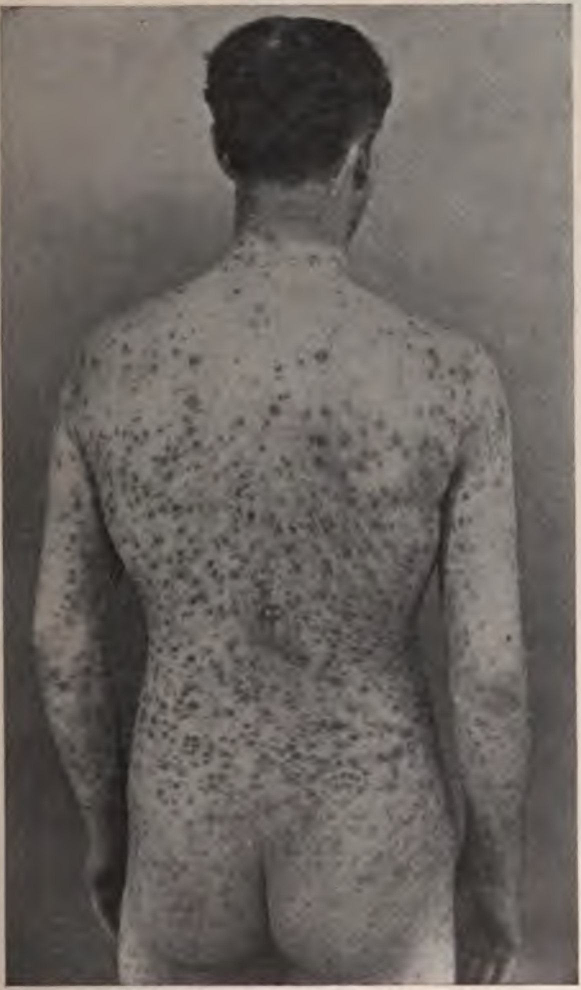


Fig. 61.—Syphilis, second stage.

point, to emphasize that the syphilids are polymorphous, unl other affections of the skin, so that one type of syphilid may found on one part and another elsewhere. Hence, papul pustular, and macular syphilids may all appear on the body one time.

Lesions of the Mucous Membrane.—One of the most const manifestations of secondary syphilis is the mucous patch wh appears on the mucous membrane of the mouth, particularly the pillars of the fauces, about the tonsils, on the tongue, or soft palate. They may be coincident with the eruption, l frequently appear before it. The mucous patch is not an ulc but a well-delimited whitish patch not raised above the surrou ing surface, and looks as if carbolic acid or a strong solution of sil nitrate had been applied to that area. Occasionally an eden tous erythema appears on the mucous membrane of the mou and pharynx. These lesions are, as a rule, not painful unless ir tated by substances taken into the mouth.

Lymph-nodes that are not correlated with the primary lesi become enlarged during the secondary stage, usually, as alrea stated, prior to the appearance of the eruption. The lymp nodes of the body generally are enlarged to some extent, and, left untreated, some of them may become greatly enlarged, b certain nodes and groups of nodes seem to be subject to a p dilection, namely, the epitrochlears and the posterior chain cervical nodes, and, while other groups may be distinctly affect the presence of enlarged epitrochlear and posterior cerv nodes is rarely found from other causes than syphilis. The nc are painless, not tender, show no surface discoloration, do suppurate, remain discrete, do not infiltrate the periglandular sues, and are, therefore, movable. They are hard, and among last of the secondary lesions to respond to treatment. Ind they often remain somewhat enlarged even after an apparent has been produced.

Fever.—There is usually a rise of temperature at the be ning of the secondary stage. It may be insignificant and of sl duration, or it may continue until the patient is well under c trol of treatment. The temperature does not often rise higher t 102° F., but occasionally reaches 105° F.

It is accompanied by the usual febrile syndrome of sympto and may simulate malaria or typhoid, and, if attended with eruption of pustular syphilids and osteocopic pains, may differentiated from small-pox with great difficulty. The t perature usually returns to normal when the eruption appe but in severe cases it is likely to continue indefinitely after eruption.

Pain.—Although the syphilitic is free from pain during the first stage, and this freedom even in the chancre is a very suspicious omen, the second stage is likely to be attended with a variety of painful sensations. They may be neuralgic in character and variable, affecting different parts at successive intervals, but particularly affecting the upper part of the back, the neck, and shoulders. Pain may be especially severe in the bones—osteocopic pains. Headache is not uncommon at this stage. If the joints are painful and at the same time swollen, and the synoviæ are distended with fluid, it may be difficult, in the absence of a definite history, to eliminate rheumatism. While the above are given as points especially affected by pain in syphilis, it may appear in any part of the body and may be continuous or intermittent, and is usually worse at night.

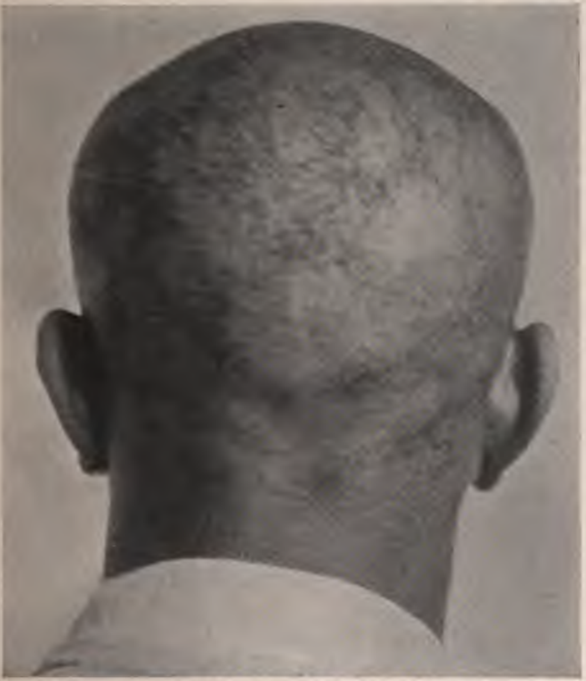


Fig. 62.—Alopecia areata in a syphilitic.

Alopecia.—Falling of the hair may occur at any time during the second stage of syphilis and may affect any hairy surface, but is especially likely to involve the scalp and the eyebrows, either of which may escape. The fact that the hair rapidly comes out in patches (alopecia areata) is very suspicious of syphilis. The skin remains smooth and apparently healthy and the hair retur under antisyphilitic treatment. Alopecia of the eyebrows is co sidered by high authority to be pathognomonic of syphilis.

Tertiary Syphilis.—Following the secondary stage the tertia syphilitic lesions may occur if proper treatment has not be given, occasionally even in spite of proper treatment. It is t tertiary stage and the late secondary that especially concern t surgeon, the stage in which ulcerative or gummatous process affect not only the superficial but the deep structures of the bod

Hereditary Syphilis.—Syphilis may be transmitted fro either or both parents to the child. It may be transmitted for very variable period after its contraction, up to twenty years more, but the further the parent from the primary sore, the le likely is the child to be a syphilitic and the less severe its diseas The child may be killed in the early months of pregnancy syphilis of the parent, and this is a frequent cause of repeated a often unexplainable abortions and miscarriages; it may go term almost and die, it may die at or soon after birth at term, it may be born healthy to all appearances and develop syphi within a year or two, which is the rule, or belong to the type know as late hereditary syphilis, and not manifest its disease before t age of puberty.

There is no primary stage of hereditary syphilis, all the lesio appearing as secondary or tertiary, and these appear side by sid

Diagnosis of Syphilis.—We are concerned here not so mu with the diagnosis of syphilis as such, when it runs a typic cours when the disease is actively present, but with the recognition it when the active stages have become history, often enough co cealed history, and when only vestiges are left here and there point us to the true nature of the condition that has caused a co sultation with the surgeon. If the history can be given by former diagnosis at competent hands, if a history of the prima sore be obtained, together with the local lymphatic involveme and later development of secondary symptoms and signs, it may unnecessary to go further. If it is the case of a child, consult tion privately with the father may clear up the diagnosis entirel But it must not be forgotten that a great many have syphil acquired or hereditary, who know nothing of the fact. Search m be made for the presence of scars, especially pigmented scars the body, but the average case does not show them. Scars of t mucous membrane, of the mouth, spots of alopeciæ on the sca or eyebrows, evidence of bone destruction, such as a flatten nose, a perforated nasal septum or perforation of the hard palat enlargement of the epitrochlear, posterior cervical or poplite lymph-nodes, an unexplainable headache or neuralgia, or involv ment of the central nervous system, as in locomotor ataxia, may lend a clue to the real status. If such evidences cannot be found, then resort must be had to one of two courses, one slow, the other rapid. First, a course of treatment for syphilis may be instituted, and if no response is observed it may sometimes be accepted as positive evidence; but the demand is frequently too urgent to dally with so slow a method, and, besides, we know that certain of the later lesions are uninfluenced by such treatment, or respond so slowly that no signs of improvement can be had within a safe limit. The second and most satisfactory plan is to make a test of the blood for Wassermann's or Noguchi's reaction, which not only gives evidence of the presence of syphilitic infection, but indicates the intensity of the infection. Syphilitics that have been and remained cured clinically for long periods almost invariably respond to this test, which can be accepted as reacting in between 95 and 100 per cent. of the cases.

Surgical Syphilitic Lesions.—Comparatively few of the changes produced by syphilis are of direct concern to the surgeon. They are especially syphilitic ulcers, syphilis of the bone, of the joints and bursæ, of the muscles, of the tendon sheaths, of the viscera, and, for the purpose of differential diagnosis, syphilis of the lymphatic vessels and nodes. It may be impressed that the most important lesions of syphilis, from the surgeon's standpoint, are ulcers and gummata, wherever situated, and syphilis of bone.

Gummata.—Before taking up surgical syphilitic lesions in detail it is necessary to consider gummatous formations in their relation not only to these surgical lesions, but as well to various other lesions with which they are frequently confused.

The nature and structure of gummata have already been discussed sufficiently for our purpose. Gummata may form during the secondary or tertiary stage of syphilis, usually the latter. When they appear early in the secondary stage they indicate a severe infection. While they develop by predilection at certain points and in certain tissues or organs, there is no structure in the body that can be said to be immune. Hence, great difficulties necessarily arise when attempt is made to differentiate them from tumors, benign and malignant, and from other granulomata. The frequent absence of syphilitic history is confusing, but the admission of such a history does not justify a hasty conclusion that the present lesion is a gumma and not a tumor.

Gross Appearance.—Gummata are more or less round masses of new-formed tissue, and are, as a rule, non-encapsulated. The size varies from that of a pea to that of a large orange, although very large gummata are very rare. On section they appear as a grayish-red, gelatinous substance, which in the older central portion may be soft and whitish. They undergo caseation and develop fibrinous tissue in their substance at the same time, but the caseation does not involve the whole mass, as a rule, as it does in tubercular granulomata, so that the zone of grayish red usually surrounds the caseating central portion. Microscopically the non-caseated portions show small spindle cells and a variety of round cells. One sees isolated giant cells occasionally. The caseating portion shows fatty granular cells, stunted nuclei, and fragments of nuclei.

Diagnosis.—Clinically it is difficult, frequently impossible, to differentiate gummata from tubercle or sarcoma, less frequently from benign tumors and from actinomycosis. When ulceration has taken place confusion arises between gumma and epithelioma. Hence, the microscope, itself often enough unreliable, may be necessary to make a differentiation; the Wassermann test and search for tubercle bacilli by staining or by inoculation will, of course, often be of service.

Syphilitic Ulcers.—From the appearance of the first sore to the end of his life the syphilitic may be subject to ulceration, except where adequate treatment has been done, and satisfactory treatment of the ulcer can be made only when its true nature is recognized. Chancre has already been sufficiently discussed; it is, therefore, necessary here to discuss only the ulcers arising during the secondary and tertiary periods.

Ulceration in syphilis may be due either to the breaking down of a gumma or an infiltrated tissue, such as condylomata about the anus or vulva, especially in filthy individuals, or to the predisposing influence of nutritional disturbances, as in syphilitic arteriosclerosis and endarteritis. We are concerned here about the former. When gummata form in or under the skin or mucous membrane and undergo caseation they appear soft at a point on the surface, rupture, discharge a gelatinous, perhaps a purulent, mass, and form a deep punched-out or undermined ulcer, which is surrounded by the indurated remains of the gumma which have escaped degeneration. The gumma may grow slowly and in a very brief time undergo the changes above given; if it has caused confusion as to its nature, such a course will indicate its true nature. Gummata of the skin and mucous membrane may be single or multiple and are often grouped, so that when ulceration occurs they may destroy the intervening tissues and cause one large ulcer, as the ulcers are prone to enlarge once they are established. After all the diseased tissue has disappeared, cicatrization takes place slowly and healing may thus occur. Some of these ulcers, however, especially on the mucous membrane, spread on one side while they are healing on the other (serpiginous ulcers), and when they appear in the lumen of the intestine are often the cause of stricture. Syphilitic ulcers are sometimes phagedenic.

Sites of Predilection.—The sites of predilection of syphilitic ulcers are practically the same as those for gummata of the skin and mucous membrane. The middle of the forehead is a frequent site of syphilitic ulcer, and the bone beneath the ulcer's base may become involved and destroyed through the thickness of the cranium and the dura be exposed. In the lower extremities gummata are frequently observed; they appear more frequently in the upper and lower thirds of the leg and on the external and anterior surfaces. Here they are usually multiple, and are one of the most obstinate types of chronic ulcer of the leg. Other sites are the forearm, arm, sternal and clavicular regions, the male genitalia, and the external female genitalia.

On the mucous membrane they are found most frequently in the mouth and nose, especially on the hard palate and on the nasal septum, in each of which they are very prone to perforate the bone or cartilage, causing a communication, in the one instance, between the mouth and the nose, and in the other between the two sides of the nose. These openings will rarely be seen except as the result of syphilis. In the pharynx gummata appear usually on the posterior wall and follow the usual course to ulceration. If they develop sufficiently low their healing is very likely to result in stricture at the beginning of the esophagus. A similar misfortune may befall the Eustachian tubes from cicatrization of syphilitic ulcers of the tonsils, producing permanent disturbance of hearing. The stomach and intestines may be involved, and in the small intestine healing may produce sufficient constriction to cause chronic obstruction. In the anus and rectum we have a very common site of syphilitic ulceration, and the resultant stricture of the rectum or anus is very suggestive of syphilis, provided it is not congenital or malignant.

Lymphatics and Lymph-nodes.—Lymphangitis may appear in the form of a hard cord leading along the dorsum of the penis, beneath the skin, during the presence of the chancre. There may be several of these cords. They are painless, and do not show the local signs of inflammation except swelling and induration. The appearance and location of the primary lymph-node involvement and that occurring in the secondary and tertiary stages of acquired syphilis have been discussed already. It only remains to say a word about the lymphadenitis of hereditary syphilis. The same rules hold for these as for those of acquired syphilis, except that the sites of predilection are very different; in hereditary syphilis the nodes involved are the same as those affected by tuberculosis, namely, the anterior cervical chains, and they cannot, by ordinary clinical methods, be distinguished from tubercular nodes. In cases of chancre of the mouth, nose, or fauces the anterior chain or the submaxillary nodes on one side will be affected.

Syphilitic nodes of the neck, secondary and tertiary, bear no relation to pathology in the nose, mouth, or pharynx, as tubercular nodes do. The nodes in syphilis are bilateral; in tuberculosis they may or may not be. In syphilis they remain discrete and movable; in tuberculosis they frequently are fixed and so agglutinated into one mass that separate nodes are no longer distinguishable. When syphilitic nodes ulcerate they produce, as a rule, larger ulcers with more tendency to slough, while ruptured suppurative tubercular nodes produce discharging sinuses. The therapeutic test and Wassermann's reaction show syphilis, while tubercular infection may be demonstrated by guinea-pig inoculation.

Syphilis of Bone.—Acquired and hereditary syphilis of the bones will be dealt with separately, with the understanding that late hereditary syphilis—*i. e.*, that producing lesions at or after puberty—is practically identical with the former.

The changes produced in the osseous system by syphilis are, first, caries and necrosis due to destruction of bone tissue by the appearance of gummata of the bone or periosteum. Second, the building of new bone tissue which may lead to bone hypertrophy, and to ossification of cicatrices which have formed as the result of injury.

Gummatous foci appear usually in connection with the periosteum and the open spaces of the bony substance. They are rarely seen originating in the medullary canal. These gummata vary in size, up to that of a lemon or small orange, and can with the greatest difficulty be distinguished clinically, and often enough microscopically, from sarcomata. Unlike the lesions elsewhere, they are very painful or sensitive. They may appear as rounded nodules or may become fusiform along the length of the bone. When incised they prove to be made up of a soft, sometimes almost fluid, substance which has a poor supply of cells, round and spindle shaped; if the small round cells are very abundant the contents may appear very similar to a whitish pus. In still other instances the substance resembles granulation tissue and tends to form scar tissue. Caseation follows and produces the usual changes in the gummatous tissue.

This gummatous development takes place at the expense of bone tissue, especially if endarteritis and periarteritis are present, and a carious process develops which produces destruction of large portions of bone tissue with no evidence of suppuration except where secondary infection occurs. This is known as syphilitic or gummatous caries. The skin over the defects, even when the bone lies close underneath it, may remain intact and even settle down into the pockets made by the bone destruction without becoming reddened or swollen. If the gummata surround large portions of bone the whole mass may become necrotic and become separated from its attachments as a sequestrum. This is a syphilitic or gummatous necrosis. It is superfluous to say that when an opening forms through the skin secondary infection is established and a purulent discharge occurs. It is accidental and is no essential part of the syphilitic process. The tibia, cranium, and clavicle are most frequently affected.

Diagnosis.—The differentiation of these processes from similar ones caused by other conditions, especially tuberculosis and sarcoma, is often difficult, and resort must be had then to the usual methods of differentiation. Syphilitic bone lesions are painful, and the pain is intensified during the hours of sleep.

Syphilitic Bone Hypertrophy.—These processes are the result of stimulation to bone development by syphilitic inflammation of the osteoplastic tissue. They may appear alone—*i. e.*, unaccompanied by gummatous osteitis or periostitis—when new bone formation is the simple result; or in connection with gummatous inflammation, when both processes work side by side, one building up while the other tears down. So an enlargement or nodules appear; the periphery may become greater while rarefaction is taking place within, or the bone may increase in size, become rarefied in spots, and have openings develop at many points leading from the surface to the medullary canal. The periosteum may be increased enormously in thickness, more than in any other disease.

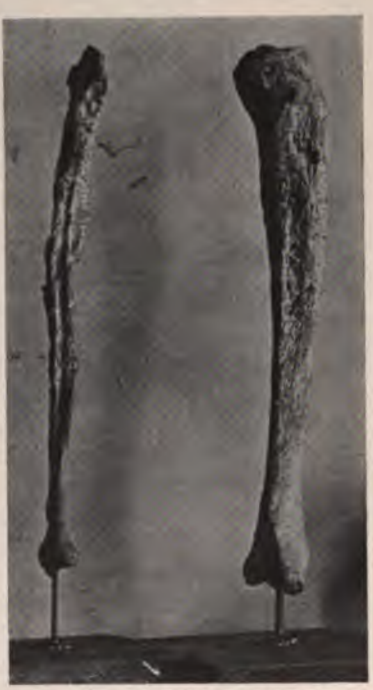


Fig. 63.—Syphilitic periostitis of fibula and tibia.

Hereditary Bone Syphilis.—As already stated, this is me
to embrace only those lesions which occur from birth to pube
There are two forms of early hereditary bone syphilis—nam
syphilitic osteochondritis and periostitis ossificans; the forme
much more common.

Syphilitic osteochondritis affects chiefly the tissues adjac
to the epiphyseal lines, especially of the femur, tibia and fib
humerus and ribs, sometimes of other bones. One or several bo
may be attacked at one time. The affection varies from an
significant, often microscopic, change to marked deformities
the bone, producing clinical signs and symptoms, and responsi
for lesions or serious accidents to the bones affected. The les
consists essentially in the deposit of lime-salts in the affec
tissue; the normal epiphyseal line and the whitish mass extenc
places into the adjacent cartilage. This is the simplest ma
scopic form. As the process advances the chalk zone beco
much broader, is still irregular, and friable; in this stage the
tilage may become very much hypertrophied, as in rickets,
the difference, however, that in syphilis there is an excess
lime-salts deposited, while in rickets the lime content is dir
ished. In still more severe forms the epiphysis may be very m
enlarged and thickened. Sometimes softening occurs betw
the bone and the chalky deposit, due to an osteomyelitic fo
The trabeculæ of the bone lose their regularity, and no longer sh
their normal position of lying in the axis of the bone and par
with each other. The presence of the brittle, chalky dep
renders the epiphyseal attachment far less firm than normal,
thus easily subject to separation. Epiphyseal separation, occ
ring as it sometimes does in healthy bones, shows a smooth
of separation; but in syphilitic chondritis the line of fractur
"uneven, nodulated or undulated, and friable." Occasionally
very severe cases the epiphyses are spontaneously separated,
to the absorptive influence of granulation tissue. This epi
yseal separation is the cause of pseudoparalysis (Kaufman
Variations in the length of the bone may occur, so that the b
that has suffered from osteochondritis may be either shorter
longer than normal. Occasionally gummata form in heredit
syphilis of bone.

The bones of the skull especially are affected by proliferat
lesions, and deformity of the cranium or microcephalus m
result. The most usual deformity is lack of symmetry. Nodu
sometimes form on the parietal and frontal eminences (Parr
nodes).

Syphilitic Dactylitis.—The bone lesion known as syphil
dactylitis affects either toes or fingers, preferably the lat

It occurs usually in infants, and appears as an infiltration in the digit, which may originate either in the soft tissues of the digit,

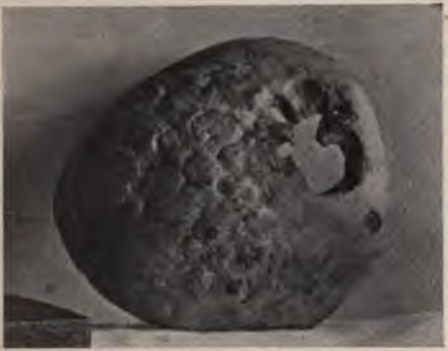


Fig. 64.—Syphilitic vault of cranium.

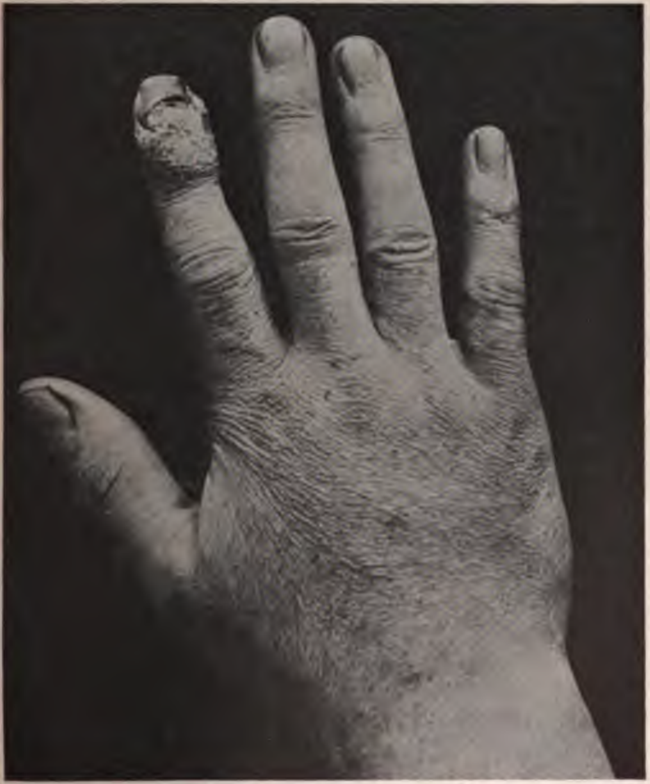


Fig. 65.—Hand of patient. Syphilis, third stage.

in the bone, or its coverings. The swelling is not clearly defined, has a cyanotic hue, and assumes more or less a spindle shape. There may be several such lesions. They produce little or no pain, and unless their true nature is recognized and they are properly treated they undergo degeneration and discharge their contents. They may destroy the bone tissue, causing a disturbance of nutrition and an *underdevelopment* of the digit.

Syphilis of Joints.—The joints are affected in various ways by syphilis, so that any lesion produced by other causes may be so closely simulated as to render differentiation difficult.

Pain.—There may be no discoverable swelling, no subjective symptom, no objective sign of disease in the joints other than pain, which is a common symptom of secondary syphilis, and resembles the osteocopic pains in its behavior.

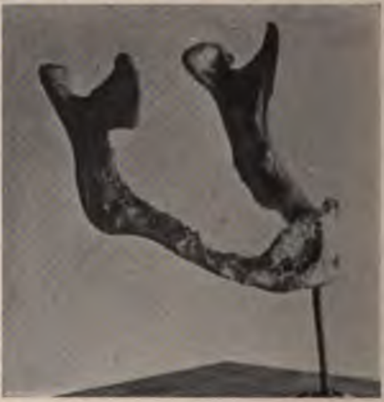


Fig. 66.—Mandible, the body of which has been almost completely destroyed by necrosis.

Synovitis.—This lesion may appear during the early secondary stage, but usually appears later, sometimes even as a late tertiary symptom. It may affect a single joint, preferably the knee, or several joints, when, if acute, it can with difficulty be distinguished from acute articular rheumatism, or it may be symmetric. The condition is either acute or chronic. The chronic form is at times very persistent and is a monarticular affection. Sometimes in the polyarticular form all the joints respond to treatment but one, which persists stubbornly and indefinitely. There may be little effusion into the synovial cavity, or a large effusion may be poured out; the synoviæ are thickened, and gummata are found in these membranes or in the articular ends of the bones and in the ligaments. Degeneration of these gummata may produce a distinct arthritis. Healing of such a process may cause marked interference with function, or the joint may become useless on account of the formation of osteophytes. Syphilitic synovitis is usually painless or but little painful, although in some instances pain may be marked. If destruction of the articular cartilages takes place, crepitation may be elicited by passive motion. The presence of painless synovitis, with considerable swelling and a surprising want of disturbance of function, should cause suspicion of syphilis, or the presence of the condition in several joints, with little or no constitutional symptoms and absence of pain and impaired function, should likewise lead to this conclusion.

Syphilis of Bursæ.—The bursæ, being structurally and functionally similar to the synoviæ, are similarly affected by syphilis. The bursæ of the knee are especially affected. The usual form of this condition is an acute bursitis coming up in the earlier part of the second stage. There may be a considerable accumulation of fluid in the sacs, accompanied by some pain and tenderness. As a rule it subsides promptly. The condition is very rare.

Gummatous bursitis, too, may appear, affecting especially the prepatellar bursa. It is painless, and is characterized by the presence of nodules and later of fluid, due to degeneration. It is at first hard and later fluctuant and is apt to rupture on the surface. Other bursæ about the knee may be similarly affected, and when degeneration occurs may rupture into the joint or on the cutaneous surface.

The tendon-sheaths are at times inflamed during the second stage (syphilitic tenosynovitis). The signs and symptoms do not differ from ordinary inflammation of these structures. The gummatous form of tenosynovitis occurs later, and usually in conjunction with syphilis of an adjacent bone. Its recognition is more difficult, and depends largely on collateral evidence of syphilis.

Syphilis of the Muscles.—Aside from the myalgia associated with the secondary stage of syphilis there are two distinct surgical lesions—myositis and gummatous infiltration.

Myositis.—This comes up during the secondary period as an acute or subacute inflammation. Its development is accompanied with contracture, which may be sudden or gradual. It is a very rare condition and affects certain muscles by preference, namely, the biceps humeri and occasionally other muscles, especially flexors. There is, as a rule, little pain except on attempted passive motion, which produces violent pain. The muscle is slightly harder than normal and shows no electric response.

The chronic form of syphilitic myositis occurs late in the tertiary stage, possibly as long as twenty to thirty years after infection. It is a diffuse inflammation, and is prone to result in new tissue formation, causing atrophy of the muscular tissue and hopelessly permanent contractures. The biceps humeri and external sphincter ani are most frequently affected, sometimes also the sternomastoid, the masseter, muscles of the arm, and the sural muscles. Pain is absent or insignificant, except when motion is attempted. The usual signs of inflammation are wanting, and only pain, as above mentioned, swelling at the beginning of the process, induration, and loss of function are to be found. As the process progresses, atrophy and cicatrization occur. Rarely it assumes the nature of myositis ossificans.

Gummatous myositis is frequently indistinguishable clinically from the above, owing to the presence of great numbers of minute gummata distributed throughout the muscular substance. When the nodules are palpable, they appear either as a single mass, which may reach a large size, that of an orange, or as several nodules distributed throughout the substance of the muscle. The sternomastoid is usually attacked; the pectoralis major, trapezius, biceps humeri, glutei, and the muscles of the tongue are other favorite sites. Gummata in muscles appear late in the tertiary stage, except in the more malignant types of syphilis. They usually appear in the belly of the muscle or at the end of insertion. They are slowly growing masses and are not painful. They may disappear under treatment, or soften and rupture on the surface, discharging yellow pus or sometimes a steel-gray pus. The resulting ulcer or sinus is slow to heal. The disappearance of gummata leaves a cicatrix which cripples the muscle to the extent of involvement. Therefore, when they are numerous, permanent loss of function may follow, and the remains of the muscle appears as an atrophied fibrous band.

Gummata of muscle are readily confused with tumors, especially with sarcoma if the gumma is single and large; with epithelioma, if it is situated on the tongue and ulcerative, and with parasitic cysts, especially cysticercus. The appearance will often resemble actinomyces when the masseter muscle is involved, but the presence of the fibrous ridge, if, indeed, it be present, leading from the atrium is characteristic of the latter. The Wassermann reaction is a most valuable differential means, but it must not be forgotten that a one-time syphilitic can acquire any of these lesions. Hence, the clinical evidence alone is not to be relied upon; a microscopic examination should always be made before radical steps are undertaken.

Syphilis of the Abdominal Viscera.—Fortunately for the surgical diagnostician syphilis of the viscera in general is quite frequently accompanied by syphilis of bone. Only those phases of visceral syphilis that are of especial surgical importance, either from the standpoint of diagnosis or treatment, will be discussed in this text.

Liver.—More frequently than any other intra-abdominal viscus the liver is affected. Affection of this organ rarely occurs during the secondary stage, but very frequently, though usually late, in the tertiary period. The type of congenital syphilis of the liver known as interstitial syphilitic hepatitis does not concern us here. The gummatous congenital type is practically identical with the acquired form.

Syphilis of the liver may be either of an inflammatory or a gummatous type or the two may be combined.

The inflammatory or cirrhotic type is the result of an inflammation developing at various foci throughout the liver, the appearance of a consequent new-tissue formation, the cicatrization of which produces the various local changes and the collateral symptoms. The cicatricial tissue develops in the form of septa dipping into the liver substance from the capsule of Glisson, and the contraction of this tissue produces in the liver the peculiar contour that has given it the name of hepar lobatum. The liver is often so distorted that it shows no resemblance to the normal; it may be contracted into a much smaller size than is requisite for normal function, or it may be further altered, either by compensatory hypertrophy or by amyloid change. The deepest retractions are usually in the neighborhood of the suspensory ligament. Adhesions may occur between the liver surface and the surrounding structures; the capsule is very much thickened, and the size of the liver may ultimately be reduced to the size of a fist, although at the beginning slight enlargement may have occurred. The whole or a part of the liver may be lobulated. The spleen may be considerably enlarged in cases of hepar lobatum.

Symptoms.—Syphilitic cirrhosis may be symptomless. When symptoms are present they are referable especially to the digestive tract. The presence of a lobulated liver, with reduction in size at one point and enlargement at another, with evidence of adhesions, should arouse grave suspicion. The patient may complain of digestive disturbances, diarrhea, vomiting of blood, ascites, and edema of the lower extremities or varicosis.

Ascites comes up slowly, but recurs rapidly after paracentesis. Albuminuria may be an associate symptom. Icterus is rare. This condition may be confused with cancer or sarcoma of the liver and with cirrhosis from other causes. The slow development of the condition, variation in the size of the liver, the absence of other tubercular foci, and positive Wassermann reaction or a history of syphilis will usually make the diagnosis.

In case the abdomen is incised the appearance of the live should lead the surgeon to a correct interpretation of the condition. The adhesions, the shrunken lobulated appearance, sometimes to the extent of almost complete severance of a portion o the liver, the presence of the most marked changes near the suspensory ligament, and, as sometimes happens, the discovery of associated, usually small gummata should remove all doubts.

Gummata of the Liver.—Gumma of the liver, like cirrhosis, is a late manifestation. The gummata usually appear on the surface of the liver, although they may sometimes be situated deeply within its substance. They may be single or multiple, and are variable in size, from the size of a hazlenut to that of an orange. They are sharply delimited from the liver substance, and may be situated so closly together that their shape is altered by pressure. They usually grow in a more or less spheric shape, except where the contour is altered by pressure. They are firm and somewhat elastic. Sometimes these gummata are surrounded by a dense capsule. Gummata of the liver are found most frequently in the neighborhood of the suspensory ligament, the portal vein, and the lower margin. Adhesions may form over the surface of superficial gummata, binding them to adjacent structures. A very characteristic feature frequently observed is the situation of the gumma in the bottom of a pocket produced in the liver surface by cicatricial contraction. On incision into the light yellowish gumma the central portion shows caseated material, and surrounding this is a peripheral zone of "grayish, glassy substance"; on the contrary, the cut surface sometimes presents a homogeneous appearance.

Diagnosis.—Manifestly, the presence of gummata in the liver may cause great confusion in differentiation. These cases are often at first without symptoms. Later inflammation of the liver or of its peritoneal covering and amyloid degeneration may occur and produce severe symptoms, causing pain in the region of the liver. Digestive disturbances may be marked and, if contraction of the liver occurs, hemorrhage from the esophagus or stomach may appear. The patient loses weight and becomes pale and cachectic. The liver is usually of normal size and is nodulated. The spleen is usually enlarged. Albuminuria is frequently present.

Gummatous hepatitis is especially likely to be confused with tumors of the liver and with distention of the gall-bladder. If the gummata are so situated as to obstruct the bile-passages, jaundice, intense and persistent, will occur, and, if they press upon the portal vein, ascites and other evidences of portal obstruction will be found. Even after incision into the abdominal cavity it may be impossible to differentiate between gummata and tumors, especially sarcomata, and resection of the liver has been performed in such cases. Tuberculosis of the liver may likewise be confused with gummata. The yellowish appearance, the hardness associated with elasticity, and the "hard, glassy connective-tissue capsule," as well as the sites of predilection, are the chief local features characterizing gummata of the liver and distinguishing them from cancer, sarcoma, and tuberculous masses.

Syphilis of the Spleen.—During the secondary stage of syphilis the spleen becomes enlarged, but does not produce symptoms. In the tertiary stage gummata may frequently develop in it, or inflammation may appear producing enlargement, induration, and slight tenderness of the organ. Leukocytosis may be present.

In congenital syphilis the spleen may be enlarged to four or five, exceptionally even to ten, times its normal size. It may contain gummata or an excess of connective tissue, which forms at the expense of spleen parenchyma. Early enlargement of the liver with subsequent reduction in size, associated with synchronous enlargement of the spleen, is very suggestive of syphilis. On the other hand, a distinct but inconstant hyperplasia of the organ may take place in congenital syphilis.

Syphilis of Pancreas.—The pancreas is seldom affected in syphilis, and when affected it is usually in the hereditary cases. The organ is enlarged and indurated from chronic pancreatitis. Gummata are rarely seen, and the condition does not produce characteristic symptoms, being overshadowed by more serious involvement of other structures. In acquired syphilis the pancreas may be inflamed primarily as a result of specific infection; this in marked contrast to the usual forms of pancreatitis, which are secondary to diseases of the gall-bladder and bile-ducts. In syphilis of the pancreas the secretory tissue may be partially or almost entirely obliterated by new-formed tissue, but the islands of Langerhans remain intact, though ensheathed by connective tissue.

Syphilis of the Testicles.—Two forms of syphilis of the testicles are seen—fibrous orchitis and gummatous orchitis.

Fibrous orchitis appears as an induration of the body of the testicle and the parenchyma disappears. The gland after a period of enlargement grows smaller as a rule; may become very small and hard. The epididymis and the scrotum are not, as a rule, affected, and there is no means of making a correct diagnosis except by collateral symptoms and signs.

Gummatous orchitis affects the body of the testicle, very rarely the epididymis, while tuberculosis begins in the latter. This is one of the most common sites of tertiary involvement, although the testicle may be affected during the secondary stage. In gummatous orchitis there is always more or less fibrosis of the testicle associated with it. The condition is usually painless, frequently bilateral and chronic, and may produce great damage to the structure before it is recognized. The gummata may be very small or reach the size of a bantam's egg. The epididymis, even when the testicle is much enlarged, can usually be recognized and is rarely invaded. The tunica vaginalis is thickened and its cavity obliterated by adhesions. Gummatous orchitis is less likely to be followed by softening than tuberculous nodules. Sometimes softening of these gummata does occur, however, followed by rupture and discharge on the scrotal surface; when this occurs, a fungus growth of granulation tissue may appear at the mouth of the sinus; this growth is gummatous and is called syphilitic fungus. The masses may disappear by resolution or become partly calcified, and finally fatty degeneration of the gummata may occur, and they be replaced by cicatricial masses. One cannot hope for resorption of old gummata which are surrounded by dense connective tissue.

It is extremely difficult to differentiate syphilitic orchitis from the other forms. The most valuable signs are the chronic course, the absence of pain and usually of sensitiveness, and the little tendency to break down into suppurating foci.

Syphilis of the Nervous System.—From a surgical standpoint the chief syphilitic lesions affect the central nervous system, and are due to the formation of gummata of the brain or meninges; they usually originate in the latter and are preceded by syphilitic meningitis, which has a predilection for the base of the brain. By enlargement the nodules, single or multiple, extend into the brain substance. Slight trauma predisposes the injured tissue to gummatous formation. Gummata of the brain, as well as other brain lesions, occur usually within the first year, and rarely after the tenth year, of infection. The symptoms produced are identical with those caused by tumors similarly located. If a basal gummatous meningitis is present, certain cranial nerves may be impaired in function by the formation of cicatricial tissue. The third nerve is most frequently affected.

Besides gummata of the brain and meninges, syphilitic nodules protruding from the inner table of the skull and from the bones of the base, may produce pressure symptoms. Syphilis of the dura and of the bony encasement of the brain is much more likely to invade the brain than tuberculosis is.

Syphilis of the spinal cord is rare; it appears in the form of gummata, which frequently are multiple and connected with some of the meningeal coats. The local symptoms are identical with those of tumor.

Prognosis of Surgical Syphilitic Lesions.—When one considers that the lesions of syphilis which are classed as surgical conditions are either the result of malignant infection, poor resistance, failure to respond to treatment, or inadequate and neglected treatment, it is manifest that the prognosis of surgical syphilis is necessarily much worse than that of ordinary syphilis. The disease belongs to medicine rather than to surgery, and it is only in rare cases of extraordinary manifestations that it is to be considered surgical. Then even only certain localized lesions are amenable to surgery; the general conditions out of which these have arisen have nothing to do with surgery. The nature, location, and extent of the lesion likewise has much to do with the prognosis. Many of the surgical syphilitic lesions refuse to respond to antisyphilitic therapy, and others create such emergency that there is no time for delay. The therapeutic test is thus shown not to be always diagnostic. If the diseased condition can be removed with safety, and if the administration of treatment be followed up afterward, the prognosis, while not of the best, is very good, provided that hopeless damage has not been done in other organs.

Treatment of Syphilis.—The treatment of the surgical manifestations of syphilis depends on the nature of the lesion and the interference it produces with function, and on the liability of spread or of continued damage to the structure in which it appears. If the lesion is causing no immediate danger, antisyphilitic remedies may be administered. If failure follows this, and no future harm is likely to come of it, the lesion may be left intact. When destructive processes begin, or when serious interference with function has occurred, and no response can be had from heroic treatment, when the emergency is such that no time can be spared, and, lastly, when hopeless permanent sequela follow, as in cases of stricture of the alimentary tract, then surgery must be done, and, other things being equal, the sooner it can be done the better the chance of recovery, for in such cases, after removal of the particular intractable lesion, the remaining manifestations respond to the usual plan of treatment. The plan of surgical treatment of syphilitic lesions is in no way different from that of similar conditions arising from other causes. For example, necrosis of bone is treated by thorough removal, gummata are treated as benign tumors similarly located would be, and stricture by the usual plans of division, incision, or resection.

At the same time that surgical treatment is done the most assiduous attention must be directed toward general treatment. The removal of the particular surgical condition is not a treatment for syphilis, but for an unfortunate consequence of its presence, and unless the surgeon's attention be directed toward the cause of the trouble, not only may he fail to get a satisfactory local result, but he may be confronted by more serious and hopeless manifestations.

The accepted treatment for syphilis is the administration of mercury. This is the treatment to be relied on as a cure in all stages. If the case has tertiary lesions, or even severe (malignant) secondary lesions, iodin should be administered in some form, usually as potassium iodid; its action as a resolvent reduces the danger from gummatous and inflammatory processes. It may be accepted, then, that both these drugs are indicated in any form of surgical syphilis. In all cases potassium iodid is administered *per orem*, but mercury may be administered by various methods and in various forms.

The oldest method of giving mercury for syphilis is by mouth. Protoiodid, bichlorid, and gray powder are the favorites in the order named. The dose should be administered three or four times daily, and should be small at the beginning, and increased to a point just short of tolerance, which is indicated by griping, purging, or blueness of the gums. Especial attention should be paid to general hygiene, particularly that of the mouth; the teeth must be kept clean. The patient's habits should be moderate and exemplary, and tobacco, alcohol, rich food, and condiments must be used in stoical moderation or preferably not at all. Abundant water should be taken, preferably alkaline waters, and the general health conserved in every possible way. All excesses must be avoided, and the treatment should be kept up continuously or, if deemed best, with occasional short intermissions.

The second method of administering mercury is by inunction—a very safe, effective, and rapid method. It is objectionable on account of the unpleasantness of administration and the time consumed at each treatment, as well as the unpleasant irritation of the skin which sometimes occurs. Unguentum hydrargyri is the form used, and it is rubbed into the skin of the abdomen, back, and inner surfaces of the thighs in daily doses of 2 or 3 drams. The inunctions should be made on different surfaces at successive treatments if the skin shows signs of irritation.

Of recent years the hypodermic and intramuscular methods of administering mercury have largely displaced the preceding two. It is more effective, quicker in action, more definite in dosage, and keeps the patient constantly under his physician's care. It is the ideal method for administering mercury to syphilitics, and is objectionable only in the slight pain at the time of injection, and the aching of the thigh and leg consequent upon the first few doses, or upon depositing the dose too close to a nerve or subcutaneously.

The preparations used for this method are numerous, the most popular being calomel and mercuric chlorid for rapid mercurialization; and gray oil, salicylate of mercury, and the iodid of mercury for the ordinary cases. The soluble salts may be administered hypodermically; the insoluble, by intramuscular injection. The injection of the insoluble preparations and all oily solutions should be guarded by the following precaution, to avoid delivery of the medicament into a vein and the resultant dangers of embolism: The needle should be filled with the mixture and inserted to the proper depth; the syringe is then disconnected from the needle, and observation made for a few seconds to determine if blood escapes through the needle or if the mixture runs out. In either instance the point of the needle must be shifted to another point and the same procedure repeated. It is unnecessary to withdraw the needle completely to accomplish this. Now the medicament is injected and a bit of adhesive plaster is stuck over the opening if bleeding or leakage occurs. In the ordinary course of treatment once a week is often enough to make injections with the insoluble salts; the soluble salts must be injected more frequently and in proportionately smaller doses. However, the dose and the frequency of administration depends very much on the individual case. In an emergency the administration should be determined by the limit of tolerance.

Salvarsan and neosalvarsan have recently been added to the list of useful antisyphilitic remedies. They are not to be regarded as cures, as it was first hoped, but as very useful drugs, especially in those cases that fail to respond to mercury, in malignant cases, in emergencies, and in those cases where serious late manifestations have arisen. Their use does not avoid the necessity of mercury and iodin, although it seems from our present knowledge that they materially shorten the time of treatment. The dose of salvarsan usually given is 0.6 gram, and it can be given either by the intramuscular or the intravenous method. In the latter instance it must be much more diluted and accurately brought to a slightly alkaline reaction. Salvarsan cannot be accepted as a harmless remedy, and is contra-indicated in all cases of arterial, cardiac, and renal lesions not of syphilitic origin.

Iodin is almost universally administered as potassium iodid. The initial doses are small, 5 to 10 gr. in solution three times a day, and subsequent doses are gradually increased till a daily dose of 100 to 200 gr. is reached. It is especially useful in late secondary and tertiary lesions.

CHAPTER XVIII

BLASTOMYCOSIS

Definition.—Blastomycosis embraces the group of lesions produced by blastomyces, one of the budding fungi. It may be simply a cutaneous disease (blastomycotic dermatitis), or nodes, abscesses, ulcers, or sinuses may appear beneath the skin and be followed by extensive cicatrization. The mucous and serous membranes, the osseous system, the lymphatics, and practically all the viscera may be involved in the generalized cases.

Etiology.—The fungus belongs to the yeast-forming group, and has been known to cause the disease over a very wide geographic area. It is found in North and South America, most of the European, and some of the Asiatic countries. The fungus as observed in the tissues is of a roundish shape, encapsulated, and has a clear zone lying immediately within the capsule. The contents of the cell are granules, which are not of uniform size and are of irregular shape. Occasionally a vacuole is found. The fungus multiplies by budding (granulation) and possibly by spore formation. It is easily cultivated artificially.

Pathology.—The pathologic changes are those of an inflammatory process, and in many ways resemble the lesions of tuberculosis, with the exception that blastomycosis is prone to produce suppuration, either in the form of miliary abscesses, so common in the cutaneous form, or large abscesses, such as appear in the viscera, subcutaneous tissue, lymph-nodes, and bones. Giant cells are present in all the lesions, and masses resembling tubercles are frequently found. The infected tissues present the ordinary findings of pus, with blastomycetes distributed through them as well as in the pus. There is scarcely an important organ within the body that has not been found affected, though the number of cases thoroughly studied has been comparatively small.

Cutaneous Blastomycosis.—This is the type most frequently seen, although it may be associated with general blastomycosis. There is a marked resemblance between cutaneous blastomycosis and lupus. It may involve only small areas of the integument, or they may be large, numerous, and widely distributed over the body. The face is most frequently affected. The lesion is elevated above the surrounding skin and has a flattened surface which has the appearance of verruca, and is ulcerated or covered with a scab. If it is ulcerated there is a purulent discharge. By pressure pus may be forced from those lesions already discharging. Surrounding this elevated surface is a sloping border, ½ cm. in width, which is of a reddish, cyanotic hue and shows large numbers of miliary abscesses, which contain a tenacious mucopus, which, on microscopic examination or culture, reveals blastomycetes. Cutaneous blastomycosis runs a chronic and uneven course, exacerbations alternating with quiescence. Healing occurs completely in some of the lesions; in others it is all but complete, with only a few minute abscesses; in still others all stages of the lesion are present, from the advancing zone bounded by the bluish-red border to complete cicatrization.

Systemic Blastomycosis.—The constitutional symptoms of general blastomycosis are less marked than the gravity of the condition would indicate. The disease is almost invariably fatal, yet the course of it is rather mild so far as the general reaction is concerned. The patients have anorexia, are weak, and become progressively weaker, until they may be prostrated. There is progressive loss of weight and increase of anemia. The temperature is inconstant, varying from an occasionally persistent subnormal registration to a maximum of 103° F. A moderate fever is the rule. The pulse varies with the temperature, as does the respiration, which is apparently not much disturbed by severe and extensive pulmonary involvement. The cases so far observed have been largely free from pain and from involvement of the lymphatics. Special symptoms arise from affection of the various organs; diarrhea may follow an invasion of the intestine, and the bones and joints may show evidence of an osteomyelitis or arthritis. Very characteristic are the subcutaneous nodules, which break down and suppurate, forming abscesses of various sizes, which rupture, discharging their contents on to the surface, and result in chronic sinuses or ulcers, which occasionally are very large, often undermined, and disposed to spread. The presence of a cough and expectoration of bloody sputum has frequently led to a mistaken antemortem diagnosis of tuberculosis, and occasionally to a similar postmortem error. Such a diagnosis is, furthermore, encouraged by the physical signs elicited by examination of the chest.

Diagnosis.—Blastomycosis of the skin may be confused with verrucous tuberculosis, with epithelioma, and with tertiary syphilis.

General blastomycosis is confused with general tuberculosis. In either form of the disease microscopic or cultural measures will be necessary to determine the cause.

Prognosis.—Cutaneous blastomycosis usually recovers, but recurrence is frequent. The prognosis in general blastomycosis is extremely grave, and the mortality is more than 75 per cent.

Treatment.—The only therapy proving beneficial so far is potassium iodid, recommended by Bevan. The drug must be administered in large doses, reaching sometimes as high as 600 gr. a day, administered with large quantities of fluid. It is unwise to begin on such large doses, but they must be reached by gradual increase in the daily dose.

Excision is of value only in cutaneous cases where the lesion is so situated that it can be completely removed. Dr. Bevan recommends sulphate of copper, gr. ¼ t. i. d., internally, and a dressing wet in a 1 per cent. solution of the same drug. *X*-rays may hasten the healing of skin lesions. Abscesses, ulcers, fistulæ, and necrosed bone may be treated according to the rules for similar lesions produced by other causes, but with much less hope for success.

CHAPTER XIX

SPOROTRICHOSIS

Sporotrichosis is an inflammatory process caused by the fungus Sporotrichum Schenckii (Beurmanni), and characterized by the formation of gumma-like nodules, which soften, rupture, and form ulcers and sinuses which run a very chronic course.

Etiology.—The fungus Sporotrichum Schenckii (Beurmanni) is a widely distributed organism, and, since its description in 1898 by Schenk and Hektoen as a disease producer, has been recognized in a constantly increasing number of cases over widely separated sections. The fungus is found on grain, trees, grass, and such like. In the United States the greater number of cases have been found in the Middle West. It has also been studied in France and Switzerland. The organism gains entrance into the tissues through an abrasion or wound, and is probably frequently contracted by man from the horse, which is also quite frequently affected.

Pathology.—The lesion, as it appears at first, is a slowly growing nodule in the form of a sphere, unless influenced by surrounding structures, as happens when it lies over a superficial bone, as the tibial crest. It is solid at first, and resembles a gumma or a sarcoma. As the disease progresses the central portion breaks down into a fluid resembling pus, less yellow than "good laudable pus," and of a waxy appearance. The pus is viscid, a very important differential point in distinguishing it from ordinary pus produced by pyogenic bacteria. It is frequently brownish or reddish brown, owing to the admixture of blood. The nodules, as a rule, vary in size from that of a hazelnut to that of a walnut. Occasionally an abscess is seen of 10 to 15 cm. in diameter.

As the destruction of tissue approaches the surface the skin breaks down and rupture occurs, leaving a round ulcer with undermined edges and surrounded by a red zone $\frac{1}{2}$ to 1 cm. in width. This border may become a purplish red or later distinctly brown. Instead of an ulcer a sinus may form. In either instance there is a continual discharge of pus from the lesion. The abscesses are lined with a thin fibrous layer and with necrotic tissue. If there are several nodes in the same region they seem to communicate with each other by narrow tracts, through which a probe may be passed, indicating that the nodules form by the extension of the fungi through the tissues.

The pus may contain small elongated bodies which resemble atypically the lumps found in actinomycotic pus.

The lymphatic vessels and nodes have not been invaded in any of the cases reported.

Symptoms.—The period of incubation was ten and thirteen days respectively in two cases unintentionally inoculated by Dind in an attempt to produce a cutaneous reaction with fluids which had accidentally escaped sterilization.

Sporotrichosis is eminently a symptomless disease. There are no constitutional symptoms. The blood remains normal, the temperature and general well being are undisturbed. The local symptoms are almost as emphatically negative. There is exceedingly little or no pain or tenderness. The diagnosis must, therefore, be made by the appearance of a painless nodule, followed by more or less numerous others scattered over the body, and situated either subcutaneously or in the muscles. The nodules are usually movable, but may occasionally be more or less attached to surrounding structures. The redness appears only as the lesion approaches the surface, but it remains (red or brown) so long as the sinuses and ulcers persist. When suppuration ceases a scab forms over the ulcer and healing occurs, leaving usually a fine thin cicatrix which gradually becomes pale; occasionally the cicatrix resembles a keloid.

Diagnosis.—Sporotrichosis must be distinguished especially from tertiary syphilis, actinomycosis and tuberculosis of the skin, and sarcoma.

The discovery of the causative micro-organism is the only positive means of diagnosis. Sporotrichum can sometimes be discovered in the pus from the nodules. Dind gives the following method of Lumiere and Becue, as modified by Galli-Valerio, for staining: "The pus is smeared in a thin layer on the slide or cover-glass and gently dried over a flame. A drop of ether is allowed to fall upon the specimen and remain for some seconds; then a few drops of a 10 to 20 per cent. KOH solution (fresh) is used; then wash in water and immerse in a 5 per cent. aqueous solution of eosin for ten to fifteen minutes; after which wash with a concentrated solution of sodium acetate until the specimen becomes a light rose-red color. Wash with water, dry by the flame, mount in Canada balsam" (Deutsche Zeitschrift für Chirurgie, 116 B).

A cutaneous reaction may be obtained after the disease has endured six weeks or more. The culture is made in fluid media and filtered. Trituration with sterile sand or infusorial earth prior to filtration gives a more marked reaction. The reaction appears in seventeen or eighteen hours and lasts two or three days. It is more accurate when administered endermically than by scarification.

When the fungus cannot be found in the pus resort must be had to cultures.

Prognosis.—It appears that the outlook for life is good, but the possibility of the physician producing a definite cure is problematic, as the lesions may continue to form under the most assiduous treatment.

Treatment.—The treatment chiefly relied upon is iodin, usually in the form of KI, administered internally, and in doses gradually increased to 200 to 300 gr. daily. It is significant that the cases inoculated by Dind were at the time receiving enormous doses of potassium iodid. R. L. Sutton recommends the additional employment of daily local applications of 1 per cent. cresol solution after the abscesses rupture or are opened.

CHAPTER XX

HEMORRHAGE

The escape of blood resultant upon injury to the parts may be upon a mucous or cutaneous surface, into one of the closed serous cavities of the body, or into the tissues where, by separation of the structures from one another, large quantities may accumulate. In all these cases the effect produced upon the patient is the same, namely, a very definite group of symptoms arising as the result of withdrawal of a certain amount of blood from the vessels and the heart. If the hemorrhage escapes directly from the wound to a cutaneous surface or an accessible mucous surface it is a visible hemorrhage; if it escapes, however, into a hollow viscus, anatomic space, or one of the serous cavities it is a concealed hemorrhage.

The extent of hemorrhage depends upon the various factors, such as the size of the bleeding vessel, the blood-pressure in that vessel, the ease of the escape of the blood after passing from the lumen of the vessel, the condition of the vessel, the nature of the wound in the vessel wall, and the coagulability of the blood. In the first place, the freedom of hemorrhage from *heart, artery, vein*, or *capillaries* occurs in the order named. An individual may bleed to death in a few seconds from an injury to a large artery or the heart, and almost as suddenly from a large vein, but the smaller arteries bleed much more rapidly than veins of similar size. Severance of the vena cava or of the aorta, as well as the heart, produces instant death, as the whole volume of circulating blood is stopped when such an injury is produced. Hemorrhage from an artery is characterized by its ejection in spurts and its red color; that from veins, by its steady flow, easily prevented by slight tension or pressure, and the dark color. Capillary hemorrhage comes as a slow, steady issue from a wounded surface, may be red or dark, and appears to well up from the tissues and not definitely from one or more points, as in arterial or venous hemorrhage.

Arterial hemorrhage is influenced very materially by the blood-pressure; hence, wounds of large arteries and of small arteries close to their origin from large arteries bleed more vigorously than those whose blood-pressure is lower. On the other hand, blood-pressure influences capillary hemorrhage but slightly, and venous hemorrhage perhaps not at all.

Hemorrhage from a deeply situated vessel of moderate size is more likely to stop short of exsanguination than one more superficially placed, owing to the tendency of the blood to clot as it approaches a surface and comes in contact with the tissues; likewise, hemorrhage from a wound made on a surface densely covered with hair is less dangerous than one of a smooth or shaven surface. If the bleeding vessel is possessed of a normal structure, the normal contraction of its muscular coats tends to reduce the rate of bleeding, but if the vessel has undergone degenerative changes the size of the lumen cannot be altered by such a process. Those wounds in which the blood-vessels are simply severed, as by incision, bleed more freely than those where the vessel is crushed, torn, or twisted in two. The condition of the blood affects its coagulability, and when, by the presence of disease or by idiosyncrasy, as in hemophilia, this essential function of the blood is reduced or destroyed, hemorrhage, even from the few capillaries injured in so minute a wound as a pin-stick, may prove uncontrollable.

Symptoms of Hemorrhage.—A relatively large quantity of blood may escape the vessels of a healthy individual without producing perceptible symptoms. But a point is reached beyond which continued hemorrhage produces marked and even violent symptoms. The effect of hemorrhage, in other words, is not in proportion to the quantity of blood lost; for if the bleeding is controlled after a considerable hemorrhage the patient may quickly react, and after a few hours show no signs of his recent loss of blood; but a very moderate additional loss may suddenly produce n alarming state which will require weeks to correct, if, indeed, it e not hopeless. This item is of especial importance in cases direct transfusion in the second sitting of two-stage operations, d, indeed, in all operative procedures undertaken subsequent a recent hemorrhage.

The symptoms of hemorrhage are pallor, showing best in the ils and the vermilion border of the lips and the mucous mem- anes, thirst, air-hunger with rapid, sighing respiration, yawning, stlessness, and anxiety. The pulse is rapid and weak and adually becomes more rapid, then uncountable, and constantly aker. The blood-pressure gradually decreases, the tempera- re becomes subnormal, the skin is pale, clammy, covered with erspiration and cold, and the patient becomes restless and anxious, nd, although he is perfectly conscious, no assurance from the attendants will abate the restlessness. The pupils are dilated and the vision is impaired. Tinnitus may be present. The patient becomes extremely weak and the voice feeble. In chronic cases of bleeding, where there is a continuous loss of small quantities of blood, or where repeated slight hemorrhages occur, the above symptoms do not appear, and the patient's appearance is that of anemia.

Control of Hemorrhage.—The control of hemorrhage may be done prior to wounding the blood-vessels or subsequently; it may be temporary or permanent. Hemorrhage from capillaries, veins, except the large ones, and very small arteries usually stanches through the natural processes of coagulation and contraction and retraction of the injured vessel, but any failure of this occurrence after a time creates a demand for the employment of artificial hemostasis. If there is any doubt as to the permanence of natural control of hemorrhage, the doubt should be removed by the use of positive methods, for often the terminal thrombi which occlude the open vessel mouths are dislodged by some accident or effort and dangerous bleeding takes place. In operative work, as has been shown already, there are other cogent reasons for preventing the escape of blood into a wound or a normal cavity.

Previous to an operation, in many regions of the body, it is convenient to render the field bloodless on account of thereby increasing the facility to work, while in other regions such a course is imperative to prevent exsanguination and the great delay imposed by the necessity of catching and ligating bleeding vessels. This is done in the extremities by the application of a tourniquet, preferably above the elbow or the knee, for it is easier to control hemorrhage in those parts containing one bone than two. In the lower extremity the tourniquet is applied preferably in the middle third of the femur, and in the upper extremity in either the upper or lower third of the humerus, to avoid paralysis of the great sciatic and the musculospiral nerve respectively by making pressure on them where they lie close to the bone. Previous to applying the tourniquet to an extremity the part may be rendered bloodless by elevating the limb or by the application of an Esmarch's elastic bandage, beginning at the digits. This plan of conserving the blood contained in the part is an excellent one, but cannot be safely practised in cases of gangrene, infection, or malignant tumors. A similar plan has been devised by Momberg for control of hemorrhage in vessels below the navel by applying a rubber tourniquet around the abdomen. Again, prophylactic control of hemorrhage may be practised not only in the extremities, but elsewhere, if the trunk arteries are easily accessible, by the application of temporary ligatures or clamps (Crile) immediately before the operation; the coats of the vessel should not be injured in these instances by too forcible compression, and the ligature or clamp should be loosened as soon after finishing as possible. In those cases where the surgeon knows he will sever the artery and its branches during his operation it is often feasible to avoid the necessity of ligating many bleeding vessels by tying the main vessel permanently at the beginning.

The time limit for obstruction of a vessel depends on the collateral circulation. In all cases where it is necessary to apply a tourniquet it should be released or substituted by other less dangerous plans as soon as possible.

Where hemorrhage is expected during an operation, or where there are bleeding points that cannot at the moment be attended to, the rate of hemorrhage may be reduced or it may, indeed, be controlled by placing a tourniquet around the proximal end of one or more extremities sufficiently tight to obstruct the veins without collapsing the arteries, "bleeding the patient into his own vessels." This has the advantage of adding a considerable reduction in blood-pressure to other applicable measures, and, further, of reserving a considerable supply of blood to be turned loose upon release of the tourniquet.

Control of Active Bleeding.—The temporary means for control of hemorrhage are those mentioned in the preceding paragraphs, together with other means of compression of the bleeding surface or of the vessel on the side of the wound from which the hemorrhage comes, proximal in arterial, distal in venous, hemorrhage. The fact must not be lost sight of that certain arteries, like the facial, bleed in both directions. This compression may be made by the fingers on the vessels concerned, or by pressure on the open surface with gauze or cotton swabs. Necessarily this is only a temporary control if the vessels are large or if they bleed actively, but it may stanch the bleeding completely and permanently if from capillaries or small veins. A needle may be passed beneath the bleeding vessel, if superficial, and compression be produced by wrapping a thread alternately around the ends of the needle and across the vessel, acupressure. If a large vessel is wounded at a point for the moment inaccessible, a finger may be pushed firmly into its lumen until it can be reached for more efficient hemostasis.

Another plan, sometimes very serviceable in the temporary control of hemorrhage from veins and capillaries, is the elevated position of the bleeding part. This is especially serviceable in operations in the cranial cavity and in hemorrhage from the pelvic organs.

Permanent Control.—Permanent control of hemorrhage is accomplished by numerous plans, all of which at times fail.

Pressure on a bleeding surface with a sterile sponge or swab, wet or dry, will usually control the smaller bleeding vessels. The addition of intense heat or cold hastens hemostasis. Unless the bleeding can be controlled by such means in a very short time, it is ordinarily better to search out the bleeding points and ligate or twist them at once. If this cannot be done, one is justified in mopping the bleeding surface with swabs dipped in boiling water. This plan is all the more feasible if the wound is of such a nature that healing *per primam* is either impossible or undesirable, as in cystotomy or prostatectomy. However, the employment of this method does not necessarily prevent primary union.

In certain instances it is not advisable or is impossible to ligate, and, at the same time, severe heat or cold cannot be employed, as, for example, in surgery of the brain, and a small vein may cause endless annoyance. Frequently such a hemorrhage can be controlled by cutting a small bit of tissue from the open wound, muscle, or dura mater and applying it over the bleeding mouth. This plan very materially aids in securing a clot that efficiently controls further bleeding (Cushing).

Another plan of controlling hemorrhage by pressure, and a very efficient and satisfactory one, is by making instrumental pressure on the cut end of the vessel with hemostatic forceps, which, when closed tightly and left *in situ* for a few minutes, will control even small spurting arteries; or by the angiotribe, which crushes the vessel proximal to the point of severance by the employment of several hundred pounds' pressure, and leaves only the connective-tissue coats unbroken, but, at the same time, each opposing wall firmly glued to the other. The bite of the angiotribe is rather wide, and vessels as large as the radial may be closed by this means. Blunk has recently introduced a shearing hemostat, which, after once being closed on a moderately large artery, may be safely removed, for it severs the intima and media, but not the adventitia, and a clot forms between the curled-up ends of the retracted coats. In cases of deep hemorrhage, or hemorrhage in parts where ligature cannot be applied, hemostatic forceps may be left, applied to the vessels indefinitely, until all danger of bleeding is past.

Ligation.—The most widely useful plan for the control of hemorrhage, as well as the most trustworthy, is the closure of the bleeding vessel by ligature, and it should be the rule of every operator to ligate all bleeding points unless they very promptly respond to less secure means. Ligatures are preferably made of catgut or kangaroo tendon, but non-absorbable materials may be used for the large vessels, and are, indeed, preferred by many surgeons. The objection to absorbable material is the possibility of too early absorption or of the knot slipping, and linen and silk are objectionable on account of the possibility of infection and the establishment of a sinus or fistula, and their retention in the tissues as a foreign substance. If a wound is known to be infected, or even probably so, it is preferable to employ absorbable ligatures as well as sutures for subcutaneous work; if non-absorbable ones must be used, they may, especially in amputations, be left long on one end, and the thread brought out through the wound so as to afford easy removal after operation; this is particularly important in those cases which are known to be infected.

The size of a ligature depends on the size of the vessel to be ligated. The smallest bleeding points may be tied with No. 0 or No. 00 catgut, and the largest with No. 2 or No. 3. The absorbability of the ligature should be determined in the same way, the smaller vessels being tied with plain gut and the large ones with twenty-day catgut, if catgut can be used. In ligating blood-vessels a single vessel should be caught and tied, and no surrounding tissue should be embraced in the ligature. The vessel should be tied at a distance from its cut end about equal to its diameter. If a satisfactory hold cannot be obtained for the ligature, it should be threaded on a needle and passed through an adjacent bit of tissue as close to the vessel as possible and then tied. There is no rule for the tension of ligatures, except that they must be tied tightly enough to hold their place. In tying larger vessels it is better to pull on each end of the ligature a few seconds while tying the first hitch, to give it time to become firmly embedded in the vessel wall. If the vessel is in a pedicle which is supported by an assistant while the operator ties his ligatures, the assistant should relax his tension while the first and the second hitches are being drawn, otherwise there is danger of slipping. The knot to be used in tying arteries should be either the reef knot or the surgeon's knot. If the arteries are hard and easily cut by ligatures, a tape ligature should be selected, or the Ballance-Edmunds ligature should be used.

Torsion.—This plan is applicable in small bleeding vessels, such, for instance, as are barely too large to be controlled by moderately long pressure. It should not be employed in any case where a hematoma would cause serious complications; that is to say, the plan is unreliable, and should not be employed in any artery large enough to spurt. Torsion is made by clamping the vessel end-on with a hemostat—a second narrow-bladed forceps catches the vessel higher up, and now the first instrument is turned transversely through two or three circles, so as to rupture the inner coats of the vessel. It is not unusual to find hemorrhage recurring after releasing the vessel on account of too much or too little torsion.

Cautery.—The use of dry heat of sufficient intensity to cook the tissues is an ancient and efficient hemostatic plan. It is unreliable in large vessels, especially arteries, for it would manifestly be an easy matter to dislodge the clot, especially in the presence of infection or as the result of exertion or other cause of increase of blood-pressure. It is to be employed especially in bleeding from small arteries and veins and in diffuse capillary oozing, especially such as is found coming from malignant growths. It is unnecessary to state that this plan is contra-indicated in cases where healing by primary union is expected; however, it may be satisfactorily employed here in parts of the wound that will be buried. Cauterization can be more satisfactorily employed if the part to be burned is clamped. In this manner it is employed as a very widely favored cure for hemorrhoids. Stretching of the cauterized surface causes recurrence of the hemorrhage. The instrument used to control hemorrhage should be brought to a red heat, *never* to a white heat, which does not control bleeding satisfactorily. The cautery must be applied to the bleeding surface until the vessels and surrounding tissues are cooked.

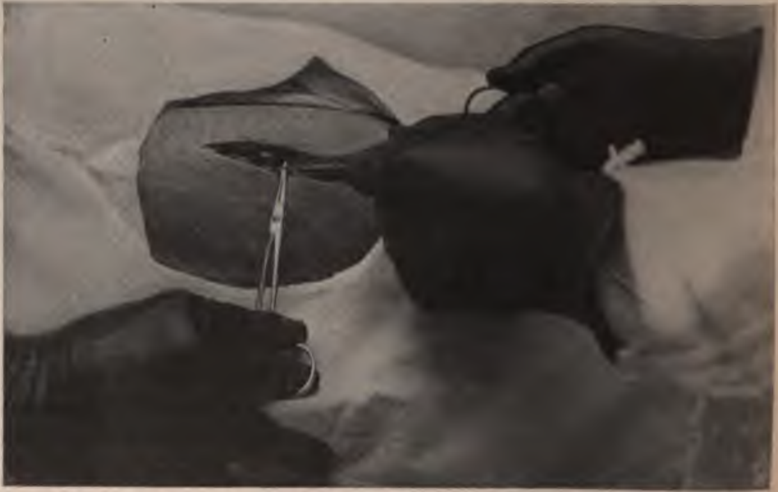


Fig. 67.—Torsion for control of hemorrhage from small blood-vessels.

Packing.—This is a plan for the permanent administration of pressure. The cavity or wound may be filled with gauze and sufficient pressure applied to stanch serious and otherwise uncontrollable hemorrhage. It often happens that a deep hemorrhage occurs, which cannot, under the most favorable circumstances, be checked by the methods heretofore given, or under favorable circumstances, when no other convenient plan presents and packing becomes the sole reliable means. In case packing is done for hemorrhage, it should be left in position for several days, often as long as a week, and even then must be removed most cautiously, lest recurrence of the hemorrhage be produced. In certain irregular or inaccessible small cavities hemorrhage may be checked by plugging the outlets and allowing the blood to check the bleeding by its own pressure when the cavity is filled. This plan is employed for hemorrhage from the nose, by packing the anterior and the posterior nares; and in uterine hemorrhage by packing the vagina. In certain instances, where a vessel emerges from a small canal and is severed so close to the outlet that ligation cannot be done, a wooden peg may be improvised and pushed or driven into the canal. I have been compelled to use this plan on a patient almost exsanguinated by hemorrhage from the descending palatine artery. This plan is also sometimes serviceable in controlling hemorrhage from a cut or sawn bone surface.

Drugs.—Chemical agents may be used for the control of hemorrhage from small vessels, but they are not generally employed to a great extent; the plan, however, is very serviceable on occasion. The drugs are astringent, cause coagulation or contract the blood-vessels, and render the tissues surrounding the bleeding vessels anemic. Monsell's solution and alumnol represent the first two of the group and adrenalin chlorid the last one. They are not to be thought of in violent hemorrhage. Sometimes adrenalin chlorid is injected into the tissues in conjunction with a cocain solution, as it increases the anesthetic property of the cocain and produces anemia so complete that only vessels of considerable size will bleed at all, or it is applied to the mucous membrane to prevent hemorrhage, but the disadvantage of these procedures is that subsequent hemorrhage is likely to occur from vessels so completely constricted by the adrenalin that no blood was left within their lumen near the incision to clot; hence, when relaxation occurs there is nothing to prevent bleeding into the wound.

Hemorrhage from bone is often not amenable to any of the preceding plans of control. If the cut surface of the bone is thin and the bone is flat, as in cranial bones, the bleeding may be controlled by crushing the thickness of the bone at the bleeding point with a Luer or other forceps. This compresses the vessels by forcing small fragments of bone against them from either side. In cases where this cannot be done, or where it fails, the proper employment of bone-wax is most satisfactory (Kocher). The wax is pressed forcibly against the bleeding surface of the bone after sponging as dry as possible and is left *in situ*. It is superfluous to state that this wax must be sterile.

Hemophilia.—One of the most alarming misfortunes that befalls the surgeon is to learn after he is under way in an operation that his patient is a hemophiliac. It is serious enough to be confronted by an uncontrollable accidental hemorrhage of this kind. After all the known plans have been tried, failure may result, and death ensue from an insignificant wound. The larger vessels can, of course, be controlled, but the bleeding continues to come from everywhere, small but constant. So hemophilia may be accepted as a most positive contra-indication to surgery. If surgery is necessary to save life a preliminary treatment should be given to increase the coagulability of the blood. This treatment is unsatisfactory in many instances, and consists in the administration of calcium salts, especially the lactate, in full doses for some weeks. A few recent cases would indicate that direct transfusion of blood from a near relative whose blood is normal is a most reliable treatment, and one whose duration at any rate extends over some months. In cases where bleeding has reached the danger point, not only is the hemophilia corrected, but the anemia is at the same time improved. Still more recently the injection of horse-serum has proved to be very efficacious in hemophiliacs.

Secondary Hemorrhage.—Subsequent to an injury and consequent upon it or some accident or complication, but not immediately, a hemorrhage may take place; this is secondary hemorrhage. Its chief danger lies in the fact that it may occur without the knowledge of either the patient or his attendants, and become alarming before its presence is discovered. Secondary hemorrhage usually occurs as the result of displacement of terminal thrombi, separation of sloughs in contused and lacerated wounds, traumatism done to wounds whose vessels are insecurely blocked, as, for example, stretching of the anus after clamp and cautery operation for hemorrhoids, and to necrosis of the vascular walls from pressure or otherwise.

CHAPTER XXI

SHOCK

In the present state of our knowledge of the physiology of shock it is impossible to define it accurately, and, one may say, to differentiate scientifically from closely allied conditions. It becomes necessary, therefore, to accept the term as representative of a group of phenomena which ensue with variable intensity upon receipt of injury.

Cause.—The appearance of shock and the intensity of it are very variable. Factors which in one individual produce violent shock cause no manifest change in another. So that, while extraneous influences play a very important part in the production of shock, the general conditions and idiosyncrasies of the individual and the part affected by those extraneous influences, especially its sensory nerve supply, all contribute their part to the symptom complex. It may be accepted at this point that shock is a reflex disturbance, rendered possible by, and established through, the function of afferent nerves or by agents capable of acting similarly on nerve centers. The causes of shock may be divided into predisposing and exciting.

Predisposing Factors.—One of the most frequent predisposing or associate causes of shock is hemorrhage. It has been long established in operative surgery that, other things being equal, the patient who bleeds is much more susceptible to shock than one in whom all the vessels possible are spared and all loss of blood from severed vessels is checked promptly and efficiently; likewise, patients who have recently suffered a severe hemorrhage develop and succumb to shock much more readily during operation. This additional fact must be borne in mind, namely, that, although the loss of blood during or preceding may be so insignificant as *per se* to cause no perceptible change in the blood-pressure or in the general feeling of the patient, still, when the exciting causes of shock are added, every drop of blood that has escaped must be considered a distinct loss in his resistance to shock.

Anemia and Malnutrition.—Patients who are undernourished, whether as a consequence of improper or insufficient feeding or who suffer either a primary or a secondary anemia, are more susceptible to the agencies which produce shock. Hence, except when imperative, surgical procedures likely to be attended with shock should be postponed until the general condition can be improved; and if surgery is immediately imperative all necessary precautions should be observed prior to and during the operation.

Infection.—The absorption of bacterial products, whether it be in case of an acute inflammatory process, a general infection, or an auto-intoxication, renders the individual less resistant to shock. This fact should be especially impressed in reference to extensive inflammations. It is thought that the severe shock consequent upon extensive burns is partially attributable to the poisons absorbed from the dead or crippled tissues.

Anesthesia.—It should be practically accepted that anesthetics favor the production of shock somewhat, and that if they are continued long in full dosage they may of themselves produce shock, and, if continued for sufficient duration, death. Chloroform is more prone to cause or favor shock than ether; the latter drug, however, is not free from this danger. The administration of abundant supplies of oxygen during anesthesia reduces the danger from shock. Hence, the so-called open or drop method of administration, or one in which the anesthetic vapor is mixed with oxygen or air by special apparatus, is preferable to the old smothering methods. Local anesthesia as ordinarily employed probably contributes little, if anything, toward the causation of shock. Its proper use in blocking large nerves supplying the field of operation, either in conjunction with or in the absence of general anesthesia, unmistakably reduces the liability to shock.

Cold.—Reduction of the body temperature by exposure to cold renders the body much more susceptible to shock. Not only so, but the exposure of raw surfaces or of serous cavities and their contents to the atmosphere adds materially to the chances of shock, and will often certainly produce it, when the operation of itself would ordinarily have no such effect. Even when the temperature of the operating room is equal to that of blood in the internal organs, the occurrence of evaporation materially reduces the heat of such wounds and surfaces. Hence, large dissections, especially if they are to be prolonged, should be covered with moist, hot towels, and the serous linings of the large cavities should be exposed only sufficiently to admit of easy performance of work. Viscera should not be held out of their proper cavities longer than is absolutely necessary, and when the necessity arises the most assiduous protection should be afforded.

Exciting Cause.—It is reasonable to suppose that any of the predisposing factors of shock above mentioned, if pushed to the extreme, might produce a more or less intense degree of shock. However, as we at present conceive it, shock is produced by an excessive stimulation of afferent nerves. From this statement two conclusions are to be drawn, namely, first, that the more abundant this nerve supply for a given part, the greater the likelihood of shock arising from interference with it, and, second, the nature of the interference is more unfavorable the more it stimulates afferent impulses. If the nerve connection between the field of irritation be previously severed or blocked by infiltration anesthesia, the possibility of shock is removed or its intensity reduced. In practical surgery shock is seen most frequently as the result of injuries, in which, if there is continued or severe hemorrhage, the symptoms become alarming and may often produce death; large dissections are capable of producing violent shock, and their liability to do so is increased by rough handling, tearing, or bruising the tissues. Hence, the necessity in such cases of cutting the tissues rather than tearing them, of clamping and ligating blood-vessels only, rather than enclosing large masses of muscle and possibly severed ends of nerves. The danger of continuing the anesthetic a little longer and of protracting the operation is far outweighed by careless handling of the tissues and unnecessary hemorrhage. The area of irritation is likewise to be considered; this is best illustrated by the statement that a superficial burn produces as much shock as a deep one; a burn on a surface well supplied with nerves more than on one poorly supplied; a large area proportionately greater shock than a small one. Besides actual gross injury to tissues, other factors, to be sure, of a similar nature may cause it; as an illustration I may cite the certainty with which traction on the mesentery is followed by it. The regions most likely to produce shock when unduly manipulated are the cranial cavity (*i. e.*, after incision of the dura), the parietal peritoneum, and the parietal pleura. The visceral reflections of these membranes do not contain sensory nerves. In dissections of the extremities and in amputations the most important factor is severance of the large nerves or irritation of their branches; traumatism to the voluntary muscles also produces shock. The pathologic conditions which most frequently produce shock are intestinal perforations, intestinal obstruction, and acute pancreatitis.

Physiology of Shock.—The exact nature of shock is unknown, and it is difficult to differentiate it physiologically from collapse and syncope. It is not quite certain, so far, that an exact measure of shock is in our possession. Reduction of blood-pressure is the most reliable means for determining the degree of shock when it is shock we are dealing with; but it is more than the reduction of arterial tension, for this phenomenon is seen in practice, and experimentally produced, without shock. Likewise in circumstances likely to produce shock the only safe means of anticipating it is a close observation of blood-pressure.

In collapse and syncope, while either of them may rarely prove fatal, recovery usually takes place in a very short time; so that if in the manner of causation they are similar to shock they differ materially in their duration. In shock there is a persistent and protracted reduction in blood-pressure which may last for days, and which rarely disappears short of several hours. The cause seems to be an inhibition of the inhibitory centers for the heart and of the vasoconstrictors. The heart centers may be affected in shock, causing an increase in its rate, with no associate involvement of the vasoconstrictor centers, but the latter are never involved independently of the former (Howell).

Symptoms.—The pulse becomes rapid and the blood-pressure low, sometimes as low as 30 to 40 mm. of mercury. Since the normal blood-pressure varies so widely, one can judge of the approach or the presence of shock, especially the less severe cases, only by comparison with the normal blood-pressure of the individual case. There is no standard blood-pressure limit, on one side of which the index would show the presence, while on the other it showed the absence of shock. The temperature, as a rule, is subnormal, but this, too, is likely to mislead, for if the temperature were much above normal at the outset it might not, even when reduced by the appearance of shock, immediately drop so far as normal. The skin is pale and cool and clammy. Respiration is slow and shallow. The reflexes are subnormal or wholly disappear. The mind is clear; delirium does not occur; the individual seems to be stunned and is incapable of quick mental activity.

Operation During Shock.—In cases which have been subjected to violence and are in shock the rule is very definite that it is better, nay, imperative, not to operate until recovery from the shock is complete, provided that the operation is not necessary for immediate removal of factors which progressively increase the shock; for example, shock is no contra-indication to operation in case the injury is associated with an uncontrollable hemorrhage, and in those pathologic conditions likely to be attended by shock it is necessary to operate at the earliest moment. The longer one postpones the operation for intestinal perforation, strangulated hernia, and acute general peritonitis, the greater the shock, intensified evidently by absorption of toxins, and the smaller the chance of recovery. However, when these conditions are associated with shock, only the judgment that comes of wide experience can guide the surgeon from interference in hopeless cases.

Prognosis.—The outcome even of severe cases of shock is, on the whole, favorable if it be uncomplicated by hemorrhage and virulent and extensive infection. When the patient begins to show evidence of reaction it is an indication that he will recover, unless additional shock is produced by operative or manipulative work. An example of this may be given—when a severe injury, such as a compound fracture, is done and shock is produced, moving the patient over a long rough journey, or manipulation to determine the exact nature of the fracture, may prove fatal.

Treatment of Shock.—The most successful surgeons devote their attention especially to the prevention of shock in their operative work; as little alarm should be produced by the preparation as possible, especially when the work must be done in the home, for there is no doubt that fright or excitement may at least favor shock; if necessary a dose of morphin or scopolamin-morphin-hyoscin should be administered an hour or an hour and a half prior to beginning anesthesia.

The anesthetic (preferably ether) should always be administered by skilful hands and only in sufficient quantity to meet the demands, increasing the amount when sensitive tissues are to be cut, reducing to a minimum when they are past. Easy handling of the tissues is necessary; cutting, never tearing, them in the larger operations. Control of hemorrhage must be done with the most scrupulous care and completeness, particularly in long operations; protection of raw surfaces and serous cavities from exposure to the atmosphere and from drying, and the avoidance of chilling the body surface by allowing the patient to remain saturated with solutions during operation, must be assiduously observed. Constant supervision of the patient's general condition will often save the surgeon from unfortunate results by seeing the approach of shock sufficiently early to do a two-time operation. This is particularly true of surgery of the brain.

The treatment of shock is very important, and should be thoroughly mastered, as the need for sound judgment in its application may arise at any time, and very wide deviation from the proper régime may prove fatal. The first, and perhaps the most important, lesson to be learned is that stimulants are contra-indicated; the inhibitory centers of the heart are out of commission, and the heart, therefore, runs away. The patient should be placed in an inclined position, head downward, or, if this is impossible, he should at least be allowed to occupy the horizontal position and the head should not be raised for any purpose. Artificial heat should be applied abundantly at the earliest moment and maintained; high temperature of the atmosphere should not cause one to forget this. The legs, arms, and abdomen should be bandaged firmly enough to prevent accumulation of blood in the vessels and to force it on toward the heart. If the patient is in pain, or restless, sufficient morphin should be administered hypodermically to relieve the symptoms. A moderate dose of it is not amiss in any case of shock. The only other drug that seems to be of much importance is adrenalin chlorid. of which 10 to 20 minims of the 1:1000 solution may be injected hypodermically, and repeated when found necessary. The injection of normal salt solution subcutaneously or intraveneously is positively indicated when shock has been associated with hemorrhage, and, although it does not appear necessary from animal experimentation, it seems unquestionably to be of great advantage in clinical work when there is no hemorrhage. In the more severe cases the intravenous method is preferable.

Crile has devised a pneumatic suit to cover the legs and abdomen, by means of which equable pressure may be produced advantageously.

As little disturbance of the patient's rest and comfort as possible should be done, and when such disturbance becomes necessary the greatest precaution should be observed to avoid causing pain.

CHAPTER XXII

WOUNDS

A WOUND is a severance of soft tissues inclusive of their covering membrane.

Infection.—It must be assumed that practically every wound produced on surfaces which have not been sterilized is infected, and this fact must be borne in mind as of prime importance in treatment. The tissues might be able to overcome the infection and thus escape inflammation, suppuration, and failure to heal by first intention. This has been placed by many in the category of poisoned wounds, but it seems to me better to reserve that term for a more restricted group of wounds.

Characteristics.—Every wound has certain common characteristics. First, there is *severance of the tissues*, frequently destruction or removal of parts of tissue. *Hemorrhage* is usually present, and is unmistakable evidence that the blood-vessels are uncovered and opened; it remains true, however, that certain wounds do not produce hemorrhage, and in these there is, instead, a discharge of lymph, usually in small quantity. This class of wounds embraces those inflicted upon non-vascular tissues, as, for example, the cornea, superficial wounds of the tegument which are not deep enough to enter even the surface capillaries, but have penetrated through the protective epithelium, and wounds made superficially by small round instruments, which when withdrawn permit the closure of the opening and prevent bleeding. *Pain* is the third common symptom of wounds. It varies with the site, the manner of production, and the nature of the wound. Pain during the production of a wound is more severe when produced slowly and by dull instruments; that from tearing is worse than that from cutting. Of course, pain is more intense in those parts well supplied with sensory nerves.

Classification.—Wounds are subdivided into *incised*, *punctured*, *penetrating*, *perforating*, *contused*, *lacerated*, *brush wounds*, *gunshot wounds*, and *poisoned wounds*.

Incised Wounds.—An incised wound is one made by a sharp, cutting instrument. They bleed freely, are painful, and, as a rule, gape. They gape more readily when made in certain directions than in others, as has been beautifully shown by Kocher. Gaping is also worse in wounds that extend deeply into the tissues than in superficial wounds; it is also worse in those produ in parts whose integument has a superficial panniculus carnos and there is a marked disposition in such parts for the skin ed to roll under when approximated; gaping is wider in woun through the scalp, when they extend through the occipitofronta or its aponeurosis, provided the line of separation lies transve to the direction of the fibers. The edges of an incised wound a smooth and clean cut, and do not show evidence of tissue destru tion. Incised wounds are the most favorable for treatment a the most dangerous from a standpoint of hemorrhage.

Punctured Wounds.—Punctured wounds are produced by elo gated, pointed instruments which may or may not have a cutti edge. The most frequent example of this wound is that produc by nails. It has a greater depth than diameter. The point entrance may appear as a slit or short incised wound if made by cutting instrument, or as an irregular or roundish opening. The is no destruction of tissue. There may be slight bleeding, but it usually very slight unless a large vessel has been cut. Pain is n marked on account of the small extent of injury to the integ ment. Occasionally a punctured wound is seen in which the i strument used—*e. g.*, a dagger—is moved back and forth aft penetrating the tissues, so that, without increasing the wou in the skin, an extensive injury is done to the deeper structure Wounds of this type, however produced, are not called pun tured wounds if they enter a normal body cavity.

Penetrating Wounds.—Penetrating wounds are those th enter a normal body cavity. They may be produced by an means whatsoever, incision, puncture, or gunshot; their cha acteristic feature is the opening of a cavity, not their method production. The cavities most concerned with such wounds a the abdomen, pleural cavity, and the cranium.

Perforating Wounds.—Perforating wounds are entirely simil to penetrating, except that they have an entrance to and an e from the affected cavity. The causative agent passes into, throug and out of the cavity. The danger of penetrating and perforati wounds consists in the fact that infection may be introduc into a large serous cavity, the viscera may be injured, and co cealed hemorrhage may take place, sometimes so rapidly th death is caused in a short while from this cause alone.

Contused Wounds.—Contused wounds are produced by instruments violently applied, such as a club, or by falls in wh the body is thrust against a flat or rounded surface. In contu wounds there is wound plus contusion of the adjacent tiss The edges of the wound are uneven, bruised, swollen, discolor and often abraded, and instead of retracting lie touching ea other or overlap. Hemorrhage is not marked; the manner of production crushes or tears the blood-vessels, so that they, even when large, often do not bleed long or profusely. Owing to injury of the tissues and subsequent sloughing, however, secondary hemorrhage is more likely to take place in these than in any other type of wound. Pain is not marked. Infection develops more readily in contused wounds than in any other type on account of extensive devitalization. In case contused wounds are produced on dense tissues, such as the scalp, it is frequently difficult to distinguish them from an incised wound. Pressure produced on the scalp between the two opposing forces bursts it.

Lacerated Wounds.—Lacerated wounds are caused by tearing, and are produced by such instruments as saws, shredding machines, cog-wheels, and such like. The edges are irregular, but less likely to be swollen and discolored than in contused wounds; they are otherwise similar to contused wounds. The tissues may hang in shreds and flaps. Secondary hemorrhage is less likely to occur than in contused wounds.

Brush Wounds.—Brush wounds are produced by the rapid movement of the tissues over a rough surface or *vice versa*. They are usually produced by moving belting, by sliding down a rope, or by emery wheels. The tissues are literally ground away. They are usually superficial, often no more than an abrasion, but occasionally extend to the muscles and tendons. They do not bleed much, but are very painful.

Gunshot Wounds.—Gunshot wounds are produced by missiles from firearms, which are the most frequent cause. The term is made to embrace also all wounds produced by bodies thrown by explosives.

The peculiar interest attaching to this subdivision of wounds grows out of the fact that the agent causing the wounds may be buried in the tissues or pass through them; the peculiar trauma produced by its passage through the tissues, the possibility of injury to various structures in its course, the danger of concealed hemorrhage or of hemorrhage from inaccessible vessels, the possibility of particles of clothing passing into the wound with the missile, and the danger of infection.

The nature of gunshot wounds is varied. They range from a small and insignificant wound, produced by powder grains being driven into or through the teguments and superficial burns, to the most extensive and dangerous mangling of the tissues; from a simple puncture or perforation of soft parts to the most horrible shattering of bones or extensive perforation of viscera. Large pieces of flesh, occasionally an entire extremity, may be blown or torn away, or a more serious injury done, with no other

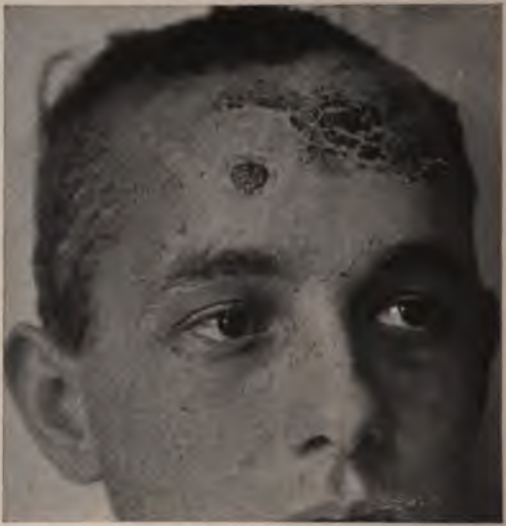


Fig. 68.—Gunshot wound of cranium showing wound of entrance of 44-caliber ball.

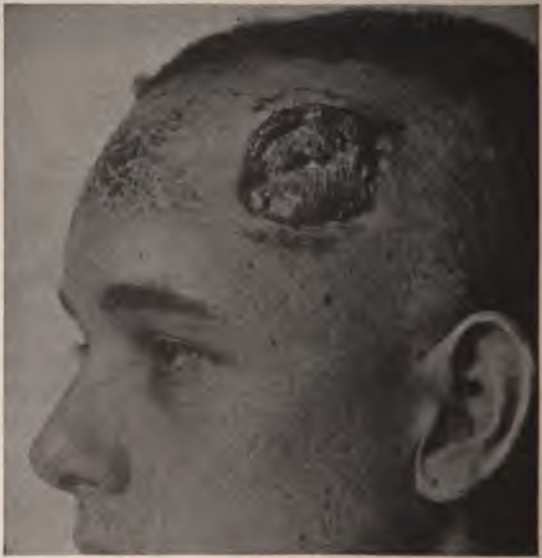


Fig. 69.—Same as Fig. 68, showing wound of exit and exposed brain. T photographs were made three weeks after injury.

evidence than a small wound of entrance and of exit. The im diate damage done in gunshot wounds depends on the size of missile, its shape, its velocity, its weight, and its resistance to impact and the kind of weapon it is thrown from. The remote effect depends on the tissues affected by the wound and the nature of the bacteria, if any are carried into the wound at the time or subsequently.

Slowly moving missiles produce contusions, lacerations, contused wounds, and fractures, and are more likely to do so if they are large and rough. If these large projectiles are thrown at a high velocity they tear away large masses of tissue. Small projectiles, which produce the vast majority of gunshot wounds both in civil and in military practice, whether thrown at a moderate or a high velocity, enter the tissues. For a missile of a given size the factors determining the nature and extent of the wound are the velocity and hardness of the missile. Necessarily the maintenance of a high velocity through the tissues depends on the weight. Soft bullets lose their shape by their impact against the tissues, and in their further passage produce, by virtue of this change in shape, an entirely different wound from those produced by missiles of sufficient hardness and toughness not to be so altered. Again, the passage of a missile through the tissues at a slow velocity damages only the structures which lie in its path;

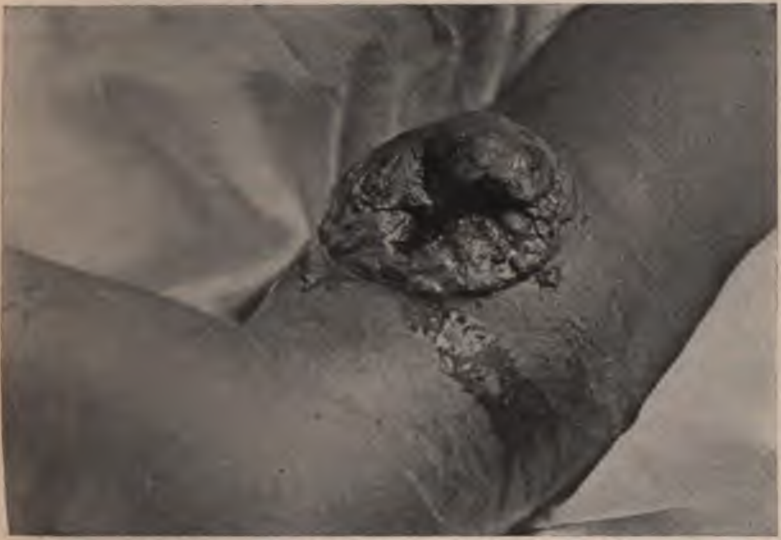


Fig. 70.—Gunshot wound of entrance, left arm, resulting in spreading traumatic gangrene and death. The skin showed no evidence of the presence of gangrene. Streptococci, colon bacilli, and numerous saprophytes were identified from cultures.

not so with missiles of high velocity, for they not only affect the structures in the track of the wound, but, by their *explosive force*, are capable of doing damage to tissues in surrounding zones of varying diameter, dependent upon the nature of the tissue penetrated and the velocity at the time of passage. The explosive force of bullets is easily demonstrated by firing a high-velocity gun carrying jacketed bullets at an empty vessel; it produces a small opening at the points of entrance and exit. But, if the vessel is filled with water and sealed and shot in a similar manner, it will be bursted or torn into fragments. Hence, as in the long-range weapons, the velocity diminishes with the distance; the damage done to tissues which are practically solid or contain fluid by explosive force will vary, being less at long range and greatest at close range. In this way a missile may penetrate tissues which are not of vital importance, and still produce death by the explosive violence done to surrounding structures.

The track of a gunshot wound may be cylindric, in which the wound of entrance and the wound of exit are of practically the same size, and no damage done to tissues lying even very near the course of the missile. The wound may gradually increase in diameter along the course of the missile, due to its having been flattened against the tissues; or the wounds of entrance and exit may be practically of the same appearance, and an enormous destruction of tissue be produced between them, by the explosive action of jacketed missiles of high velocity.

It is often of great forensic importance to differentiate between the wound of entrance and that of exit. This is especially true in civil practice; the weapons employed for this purpose usually carry soft bullets, which renders distinction much easier. The wounds produced by jacketed bullets often cannot be distinguished. The wound in the skin produced by a bullet striking at right angles to the surface is usually round, and apparently somewhat smaller than the diameter of the ball producing it. They are sometimes in the form of a slit, especially if situated in a crease of the skin. If the impact is at an angle the skin on the acute side is abraded and beveled. If the weapon was fired at close range, the surface is burned or blackened and shows powder grains driven into the skin. The wound of exit is larger, sometimes much larger, than that of entrance, is often fissured at its periphery, everted, and more ragged than the wound of entrance. It shows no evidence of powder marks or of burning. There may be a slight amount of bleeding from either wound; it is severe only when large vessels have been opened, but if these vessels lie in a large cavity or in a loose tissue the hemorrhage will reach the surface only in small quantities unless the wounds are unusually large.

Hemorrhage is not constant even when large vessels are perforated. I have seen a case in which both popliteal artery and vein were perforated with no hemorrhage; the result was an arteriovenous aneurysm and gangrene of the foot.

The degree of shock produced by gunshot wounds depends on the tissue injured and on the size and velocity of the ball, and, of course, on the amount of associated hemorrhage. Large missiles produce greater shock than small ones, and those of high velocity produce greater shock than those of lower velocity.

The course of a missile after entering the body can only be conjectured. This is true whether there is both a wound of entrance and of exit or only one of entrance. The missile is deflected by its impact against the tissues, especially the bones, and often takes a course at great variance with the line of its original direction. Even the skin may serve to deflect the ball, and though wounds are seen which by the relative location of the points of entrance and of exit would lead one to believe that a cavity had been perforated, they are, in fact, little deeper than the subcutaneous tissue. Any tissue of the body may be injured by the passage of a bullet, but with ordinary arms of low velocity the blood-vessels often escape miraculously by being pushed aside by the passing ball. However, missiles of high velocity sever the vessels.

Infection.—While it is demonstrably true that missiles are not sterile, and are not sterilized by being shot from a gun and passing through the atmosphere, and while it is further true that frequently small bits of clothing are carried into the wounds, it is the rule for gunshot wounds, if left undisturbed, to run a non-inflammatory course and to heal without complications, except such as grow directly out of the structures injured. Most of the infection seen in gunshot wounds is due to failure to protect them by antiseptic or aseptic dressings and to the continued practice of the antiquated and baneful habit of probing every gunshot wound, or by the willingness of the surgeon to yield to the temptation to undertake the removal of the missile. Most cases of infection are due to this cause; and this is not all, the tissues are often further injured by such practice.

Poisoned Wounds.—This group of wounds, formerly stressed in surgical texts, has come to be of slight significance from a surgical standpoint. All contaminated wounds may be subdivided into two groups. Of these the first and most important is infected wounds, the nature of which will be easily understood by a study of the chapters on Bacteriology, Inflammation, and Suppuration. The second group is poisoned wounds proper, which are wounds into which a local or systemic poison is injected at the time of infliction, as illustrated by the bite of venomous serpents and the sting of insects. Formerly, wounds inflicted by weapons which had been contaminated with earth containing bacteria, notably tetanus bacilli, were embraced with poisoned wounds, but patently they belong to the first group. However, implements of warfare which carry chemical poisons instead of bacteria produce poisoned wounds.

The characteristics of poisoned wounds depend on the nature of the poison. In one instance they are entirely local, as in stings, and in another, as in the bites of serpents, they may be both local and constitutional, but the latter is the more important, for the mischief is done by the general effect of the poisons on the tissues.

Surgical Wounds.—Wounds produced by the surgeon in the routine of his work are the incised, the punctured wound, and crushing of the tissues; the latter, which may be described as an orderly kind of contused wound, and is usually associated with excision of the tissues distal to the level of crushing, occasionally is necessary. Occasionally the subcutaneous tissues are torn properly in surgical work, but this plan is coming more and more into disrepute, and will ultimately be employed for such minor purposes as Hilton recommended; for example, in opening certain abscesses.

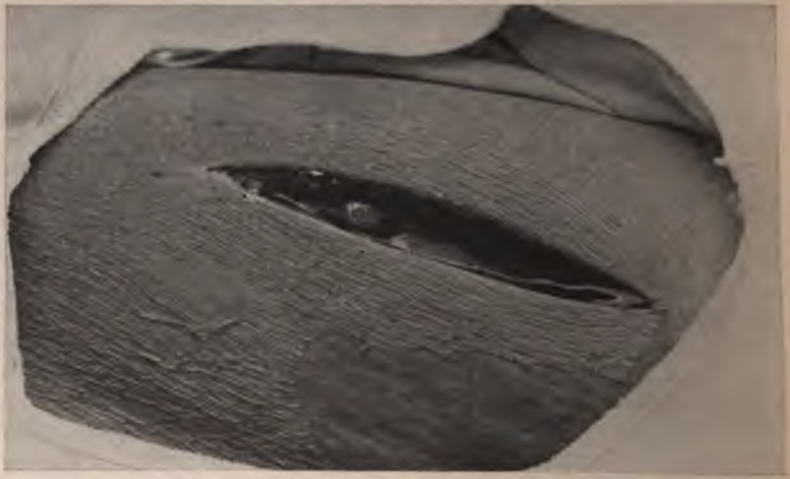


Fig. 71.—Incised wound correctly made.

Incised wounds should be made in accordance with definite rules. The incision should always be made in a plane perpendicular to the surface, otherwise the edges will be beveled and the approximation will be poorly done. The ends of the incision should be vertical, as nothing is gained by extending the cut obliquely to the epithelial covering. The incision should always be made rapidly with a sharp knife, and should be of sufficient length to allow easy performance of the work.

Punctures are employed for the localization or the withdrawal of pathologic products and for the administration of drugs. The instrument may be inserted directly and quickly into the tissues, with or without a previous puncture of the skin with a bistoury. If there is danger of leakage after withdrawing the instrument, or if there is fear of infection being afterward carried from the surface along the tract of puncture, a safeguard may be established by sliding the skin as much as possible to one side and then puncturing. When the work is finished, and the skin resumes its normal station, the opening in it will be more or less removed from that in deeper structures. If the cavity aspirated is under tension and leakage is feared, insertion of the instrument obliquely is the best safeguard.

Crushing the tissues in surgery is done for two purposes, namely, the control or prevention of hemorrhage, as seen especially in the clamp and cautery hemorrhoid operation, and for the purpose of pressing certain tissues out of the way, as illustrated in appendectomy, where, by the employment of this plan, the mucous membrane is forced away from the bite of the clamp and only the tougher sterile tissues are embraced by the ligature.

Treatment of Wounds.—The first step in the treatment of wounds is to control hemorrhage; this may be done immediately by temporary means until facilities for permanent control can be had. The loss of large quantities of blood is so detrimental to healing and so favorable to the invasion of bacteria, aside from the possibility of immediate death, that hemorrhage, if at all free, should be controlled even at the sacrifice of other important surgical principles. Hence, when bleeding is endangering life there may be no time (such occasions are not frequent) for preparation of the hands or sterilization of instruments; so, too, the presence of even severe shock is an urgent indication rather than a contraindication for the control of hemorrhage at any risk and by the most rapid and direct method. After the hemorrhage is checked, one may postpone further procedures until the patient's condition warrants them. In operative work control of hemorrhage should be made immediately before or after its appearance.

The second step in the treatment is to cleanse the wound and the surrounding field, except, of course, in operative work, where previous preparation renders this step superfluous. This is a most important item in wound treatment, and one that is too often accepted as impossible, and, on the other hand, one often rendered much more difficult on account of the various unclean applications employed by the laity for control of hemorrhage or for the promotion of healing. The first lesson to learn in this regard is that after bleeding is checked it is better to leave the accumulated clots on the wound surface until one is ready to proceed with the work along aseptic or antiseptic lines. This rule obtains in cases, too, where a sterile emergency dressing is at hand. The blood is a far better protective than any substitute, and removal of the clot is almost sure to result in infection. The region should be shaved and scrubbed, and then sterilized according to one of the plans already enumerated under skin sterilization. The best plan is to use benzin instead of soap for shaving and to sterilize with iodin. All foreign bodies must be removed, such as cinders, dirt, hairs, etc. The wound itself is now cleansed of all clotted blood and fragments of tissue, and an attempt made to rid it of possible bacteria. This is best done by irrigation with saline solution or alcohol, or by swabbing it out with tincture of iodin, 1 to 3 per cent., or with carbolic acid followed with alco-

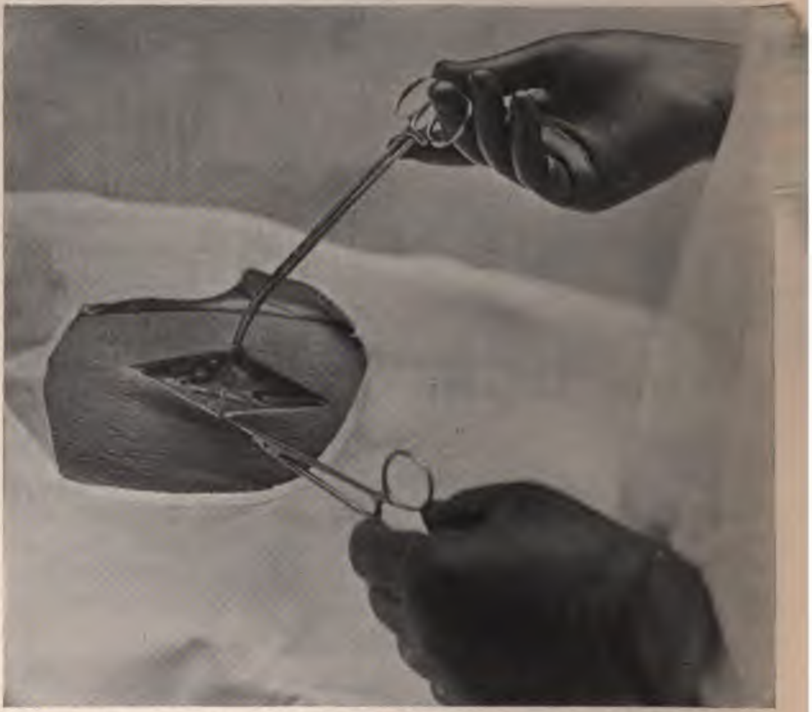


Fig. 72.—Correct method of holding skin at upper lip. Incorrect at lower lip. The hemostats necessarily devitalize the tissues and favor infection.

hol. These agents interfere but little with primary union, and are very satisfactory unless their application is made some hours after the injury, *i. e.*, after the bacteria have had time to bury themselves in the tissues. All devitalized tissue should be removed by knife or scissors; it may be accepted that all vascular tissues are devitalized if they show no bleeding points on incision. Such tissues must be removed, for they will slough away and serve as a fine culture-medium for infection. Shreds and fragments of living tissue, too, that cannot be secured in position, as in lacerated wounds, ought to be removed. Finally, one must see to it that the wound is as dry as possible, and that all oozing of blood has been stanched before the next step is undertaken. Cleansing punctured wounds and control of hemorrhage can only be done by slitting them open.

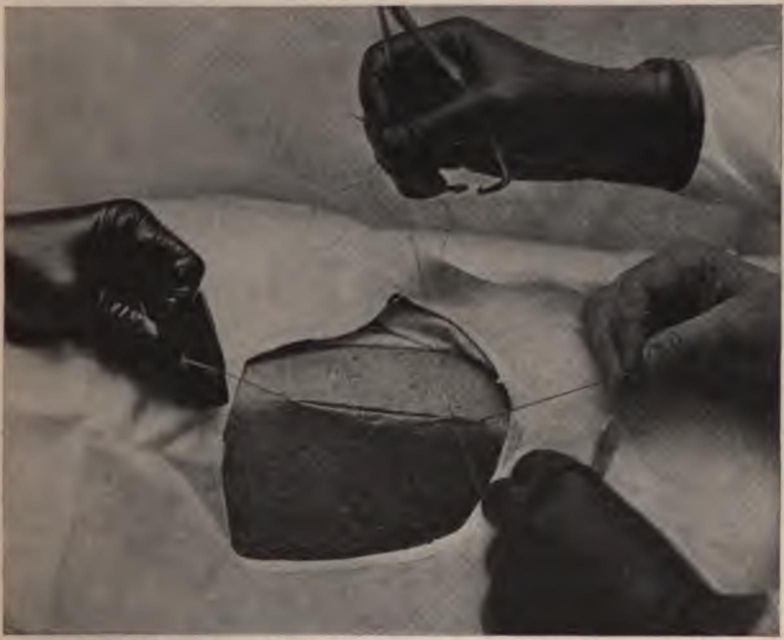


Fig. 73.—In closing the skin traction by sutures or vulsella prevent the edges from rolling inward.

Closure of the wound now follows if, indeed, it is deemed best to close it, or if it is possible. Certain wounds are purposely treated as open wounds, and held open by packing, as, for example, those in which there is a possibility of tetanus or other anaërobic infection, and those which by their nature cannot be closed. Moreover, other wounds demand drainage, especially those that are large and have large areas of damaged tissue, or in which bleeding cannot be satisfactorily controlled. In cases where great swelling has already occurréd it may be impossible to make a satisfactory closure and the suturing may be postponed until the swelling subsides.

The purpose of closure of wounds is not simply to repair the breach in the tissues, but to follow a definite plan and restore the tissues as nearly to their normal relation and function as possible, and to accomplish healing with a minimum of scar tissue. Therefore, in closing wounds it is proper, with rare exceptions, to approximate like tissue to like, peritoneum to peritoneum, fascia to fascia, skin to skin, for, in whatever position the approximation is done, they will remain permanently after union. On this account it is preferable, where the wound extends through several superimposed structures, to close it with several layers of sutures, one for each important structure concerned, for it is impossible to accomplish the same satisfactory reposition with through-and-through sutures.

It is necessary in closing wounds that the edges be approximated snugly, with no dead space in the depths of the wound. It is just as necessary that the sutures shall not be drawn tightly enough to do more than this, a practice that is too often seen even in surgeons of fair experience. If the suture is drawn tightly enough to obstruct circulation in the tissues within its grasp it will delay union, and if it cuts the circulation off necrosis will of necessity occur and infection very probably, or the sutures may cut through the tissues and lose their value altogether in addition to unnecessary crippling of the tissues.

The closure of wounds is usually effected by sutures. This is universally practised in the deeper structures. Closure of the skin may be done by sutures, clips, or adhesive dressings. The former two are preferable, and if there is much depth to the wound it is better to employ sutures to close the whole of it, or all but the skin, to avoid dead spaces. Sutures should be placed sufficiently far from the edge to serve their purpose, a rule that varies both with the amount of tension imposed and the toughness of the tissues; it is necessary to place sutures in the ends of severed muscles much further back than in fascia or skin. If it is desired to have as small a scar as possible, the sutures should be fine and placed as close to the edge as possible and removed early. Early removal lessens, too, the chance of stitch-hole abscess, a very important fact in connection with two-time operations.

Those wounds which cannot be closed without dangerous tension on the sutures should have the tension relieved by relaxation sutures or by adhesive strips, which are caused to extend a satisfactory distance away from the cut edges. If these methods produce too much tension on the adjacent structures and threaten necrosis they should be abandoned, and the parts must be dissected free sufficiently far to allow easy approximation. If this is not feasible the wound must be left to heal by second intention, or covered by grafts at the time or subsequently. The most important factors in suturing are closure, avoidance of tension, of constriction, and of fat or other materials between the sutured edges.

The materials employed for suturing the soft parts are, according to the practice of the majority of surgeons, very well established, although there are many exceptions. Removable sutures may be made of any material that has sufficient strength, provided it can be sterilized; they may be absorbable or non-absorbable, with a great preference for the latter, inasmuch as absorbable suture material in the skin is more favorable to infection. Silver-wire, silk, or silkworm-gut, and Pagenstecher's celloidinized linen are commonly employed. The wire and silkworm-gut sutures have the advantage of having little capillarity, being impervious and less favorable to infection, but they are more difficult to handle, and likely to irritate the surface unless their free ends are protected. Silk is more permeable to fluids and bac-

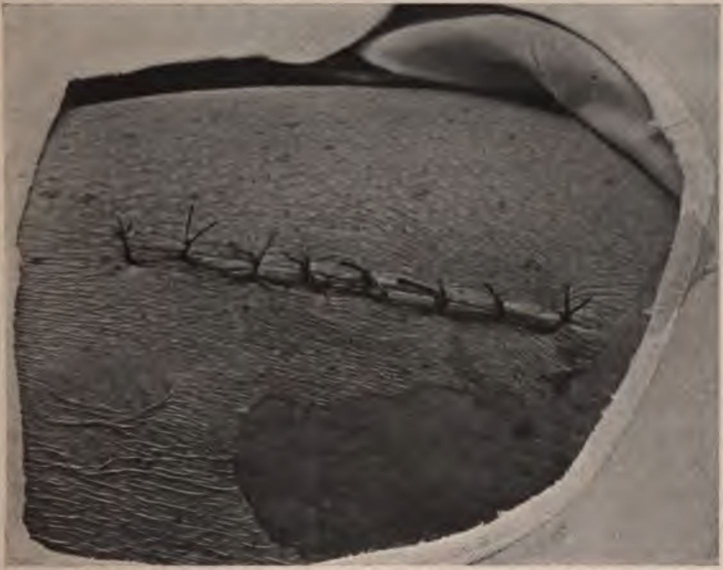


Fig. 74.—Wound sutured and ready for dressing.

teria than linen. In buried sutures catgut and kangaroo-tendon are preferred by the majority of surgeons, for reasons previously given. However, in the peritoneal cavity non-absorbable suture material may be used with just as little risk as absorbable, provided it is not an infected case; but in cases of peritonitis it is better to use catgut, for, while it is more likely to become infected, it cannot serve as a permanent nidus for bacteria and thus maintain a sinus indefinitely. After a clean wound is closed it should be covered with a sterile dressing, which is left in place from five to eight days, when the sutures will be removed, unless local symptoms, soiling, or constitutional symptoms demand inspection of the wound.

Treatment of infection, inflammation, and suppuration in wounds is not different from the rules already laid down, except that when suppuration is imminent a sufficient number of sutures are to be removed to allow free escape of fluids.

In all large wounds, especially contused or lacerated, if infection is certain, it is better to close with drainage from the beginning or to treat for a time as an open wound. The repeated or continuous employment of antiseptics in the treatment of even infected wounds is demonstrably harmful and should not be employed. The treatment in such cases should be along the lines indicated in the treatment of inflammation.

Treatment of Gunshot Wounds.—In gunshot wounds which resemble incised, lacerated, and contused wounds and such like the treatment is the same as in wounds produced by ordinary causes. It is in all cases, of course, theoretically preferable to remove the bullet, and this is often insisted upon by the patient. Practically, it is rare that a bullet fails to be encysted and rare that it gives serious trouble *per se*. The facts of correct practice may, therefore, be stated as follows: If a bullet lies close to the surface, and may be readily excised without increased risk to life or damage to tissues, it may be removed according to choice; if, by virtue of the position of the missile, it interferes with important function the surgeon must decide whether removal is more hazardous than to leave it, and act in accordance with the best interest of his patient; if, by virtue of infection or other complications or sequelæ, necessity arises for excision, it may be undertaken when such necessity arises. The plan of digging about in the tissues for a bullet that has little chance to produce harm should by all means be abandoned.

Ordinarily the treatment of gunshot wounds may be subdivided into immediate or prophylactic treatment and subsequent surgical treatment. It is best that an antiseptic dressing be applied as soon as possible after receipt of a gunshot wound. In keeping with this fact, the leading armies of the world have an emergency package supplied to each soldier, who is instructed how to use it. The sole object of this package is prevention of infection and hemorrhage, and a wound in which hemorrhage is not severe may be securely protected until the surgeon can reach him. Infection from fragments of clothing carried into the wound is not of sufficient frequency to alter the rule. It is better to wait for infection to develop in these cases.

In all cases of gunshot wounds attended with free bleeding operation must be done at the earliest moment, regardless of shock and the location of the bullet, unless by temporary means the hemorrhage may be controlled. Most of the soldiers who die on the battlefield die of hemorrhage. But no time should be wasted searching for bullets.

In all cases where the missile has entered the peritoneal cavity the abdomen should be opened at the earliest possible moment after control of the bleeding, perforations should be sought for, and treated by closure or excision as the case may demand, and subsequent treatment, according to the combined plans of Murphy and Fowler.

If the ball enters the pleural cavity, and there are no signs of hemorrhage, the indications are to seal the wound of entrance and of exit artificially, and await developments, meeting them promptly as they arise.

Gunshot wounds of the cranial cavity are to be dealt with according to the rules already given, with the addition of certain special indications. If there is depression of bone, or compression due to subsequent hemorrhage, such pressure must be relieved as soon as the condition of the patient and circumstances will permit. The ball when not easily accessible, as indicated by skiagraphs made in planes at right angles to each other, should be left tentatively *in situ*, unless it is causing dangerous symptoms. The passage of missiles of high velocity through the brain produces instant death by their explosive force.

Poisoned wounds are treated according to the nature and quantity of the poison. The stings and bites of insects deposit an acid poison into the tissues, and, unless the number of such wounds is great, cause no demand for treatment beyond immediate relief of the local symptoms; this indication is best met by the application of an alkaline solution, which is supposed to neutralize the poisonous acid to some extent. Snake-bites, as well as those of other venomous reptiles, demand immediate attention, as they very frequently prove fatal. First, the wound should be freely and deeply incised at the point of entrance of each fang, and abundant hemorrhage from the capillaries should be encouraged by moderately tight application of a tourniquet above the wound, or by suction, thus extracting as much of the poison as possible from the tissues; or the tourniquet may be applied tightly, so as to shut off all circulation until other measures may be employed. It is not the wound *per se* that concerns us here, but the hypodermic injection of an absorbable poison. Patients who are subjected habitually to the risk of such wounds may be immunized by the use of antivenomous serum. The treatment of the general condition is to be directed along the line of stimulation, for which strychnin is the preferable drug, being used in enormous doses with great advantage; whisky in large doses is likewise a favored remedy; supportives and tonics; the body temperature must be maintained by artificial heat and elimination must be encouraged, but not to the point of exhaustion.

CHAPTER XXIII

BURNS

A BURN is the pathologic lesion resulting from the action of heat of such intensity as is incompatible with the integrity of the tissues.

Etiology.—The causes of burns are very variable. They are the actual flame, contact of the tissues with or their close proximity to heated objects of whatever nature, exposure to radiated heat, as is illustrated by exposure to the sun's rays, exposure to steam, hot air, or other gases, the application of hot liquids (scalds), electricity, and x-rays and radium. The term "burn" is also applied to the lesions resulting from the action of acids and other chemical (potential) cauterants.

Degree of Burns.—Ordinarily three degrees of burns are mentioned, although there is a recent tendency toward the acceptance of a fourth degree.

Burns of the First Degree.—Burns of the first degree are those in which the action of the heat has been only sufficient to cause redness of the skin due to active hyperemia, followed by paresis and wide dilatation of the affected blood-vessels and a passive filling of the vessels. The most common example of this type of burn is sunburn. It is also seen sometimes resulting from the action of heat applied for therapeutic purposes. The characteristic features of burns of the first degree are erythema, pain, which is invariably of a burning character, and slight swelling of the affected area. The pain is invariably exaggerated by exposure to heat or to the sun's rays. These symptoms are at their height in from four to twelve hours after receipt of the burn, and from that time gradually subside and are well in two to four days. The young, and those who are not habitually exposed to heat or sunlight, are much more susceptible to such burns, especially sunburn. After the skin has been exposed sufficiently long to the sun's rays it becomes "tanned," and after this is much less susceptible to sunburn. After subsidence of the inflammatory process the redness gradually disappears, the skin becomes browner than it was ("tanned") if the burn is a sunburn, but not otherwise, and the devitalized layers of epidermis desquamate in large, thin, veil-like pieces.

Burns of the Second Degree.—These are the burns in which the formation of blebs occurs, and the three outer layers of the epithelial covering are lifted away from the rete mucosum by the accumulation of serum between them; this accumulation is almost instantaneous. The most frequent burn of the second degree is the result of scalds, steam, or hot gases, and by the combustion of inflammable fluids (gasoline) in contact with the skin. The second degree burns are often attended by more or less extensive first degree burns. The fluid distending the vesicles is straw colored and often coagulated. This seems to be especially the case where the heat has been held for some time in contact with the surface, as in cases where molten iron has been spilled in the shoe. The presence of the blebs, which may be ruptured or intact, dependent upon the thickness of the skin, and pain are the characteristic local symptoms. If the blebs have been ruptured in burns of the thick skin of the palm and the sole, the burned skin is drawn into a creased or fluted wrinkled shape. The pain is severe, and is intensified by exposure to ordinarily harmless degrees of heat, or by removal of the cuticle and exposure to the atmosphere and by infection. It remains intense for a few days and gradually subsides as healing occurs; it is protracted indefinitely by infection. Healing of burns of the second degree should be attended by no scar-formation unless infection occurs.

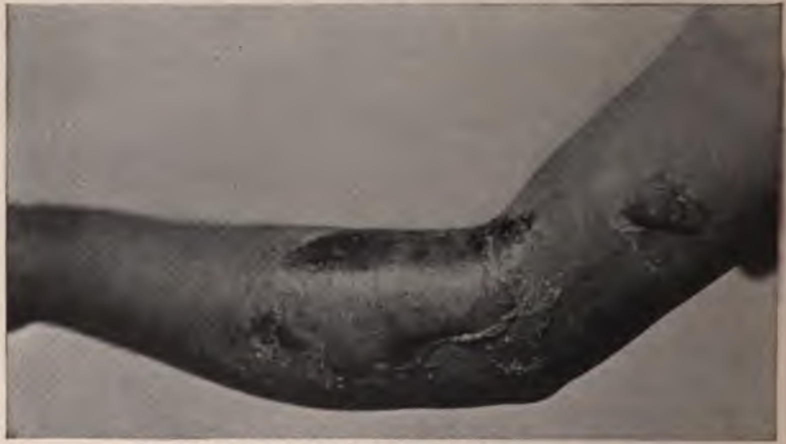


Fig. 75.—Scald of second degree of left upper extremity.

Burns of the Third Degree.—In this, according to the older standards, intensest form of burns the burn may extend slightly or vastly deeper than in burns of the second degree. When the cutis is burned, with or without destruction of the underlying structures, it is known as a burn of the third degree. It includes all burns in which an eschar is produced and cooked or charred tissues found. It is the type of burn that invariably results in the formation of an ulcer, when the eschar is separated from its attachments by the process of granulation. Burns of the first and second degree may be associated with it. Furthermore, it is the type of burn that invariably and necessarily results in scar-formation, regardless of the presence or absence of infection, and is productive of all the hideous cicatrices and deformities that affect those who have had severe burns. These scars may develop into keloids, or later develop a Marjolin's ulcer, or produce epitheliomata. Of 1720 cancers studied by von Neve, in India, 848 were cancers of the upper thigh and abdomen consequent upon scars produced by the custom of the natives of carrying fire-baskets under their clothing. The occurrence of burns and scalds in the mouth and throat may cause most urgent symptoms by becoming complicated with edema of the glottis, which may require tracheotomy or intubation to prevent asphyxiation. The local symptoms of burns of the fourth degree are *per se* less intense than those of the second, owing to the fact that fourth degree burns destroy the cutaneous nerve-endings; but, inasmuch as the other two degrees are always present, the presence of pain is to be noted as the important symptom.

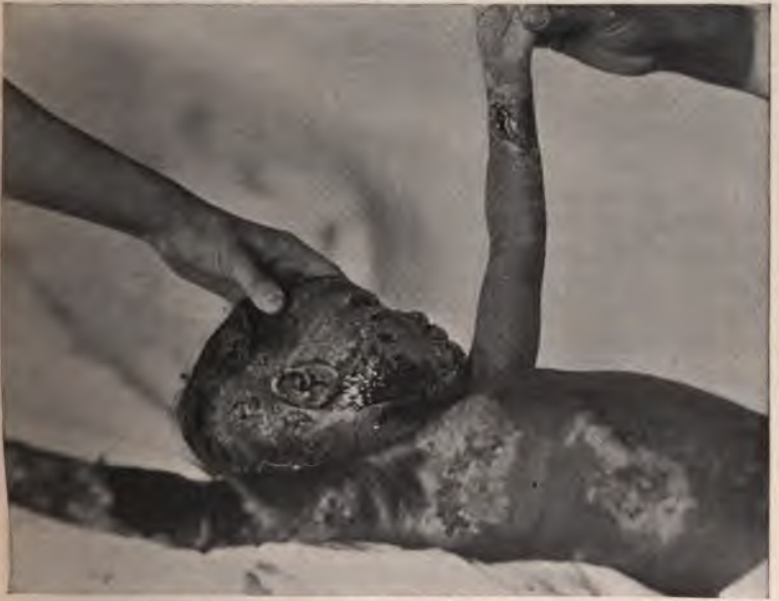


Fig. 76.—Severe burn of third degree, recovering.

Burns of the Fourth Degree.—This is sometimes used to signif those burns in which the burned tissues are completely charre or when a part is exposed to prolonged intense heat the tissu are carbonized, and the process is called carbonization.

Pathology.—The local pathologic changes of burns of the fir and of the second degree are apparent from the preceding di cussion. Those of the second degree are capable of resulting i cicatrices only when suppuration occurs and destroys the papill of the skin, being, therefore, amenable to control by correct trea ment. In burns of the third degree the tissues are cooked or ca bonized. The vessels of the skin, if it is not too completely de stroyed, appear on the burnt surfaces, in the form of dark-brow arborescent figures, an important fact in forensic medicine, fo these figures do not show when the body was dead prior to th burning. It is superfluous to add that if the large vessels ar affected thrombosis occurs.

The general pathologic changes are insignificant, and do no suggest an adequate explanation for death. Ecchymosis of th mucous and serous surfaces and in the muscles is found; edem of the brain and the meninges; occasionally duodenal ulcer thrombotic and infective origin; and certain changes of the viscer indicative of intense intoxication, even when death has occurre so early as to eliminate the possibility of an explanation on th hypothesis of infection; they are degeneration of the heart muscl kidneys, and liver, with endothelial swelling and proliferation i the lymph-nodes, similar to the changes found in acute infection (Adami).

Constitutional Symptoms.—The manifestation of constitu tional symptoms depends both on the degree and the extent the burn, but more especially upon the latter, and upon th presence or absence of infection. Small burns of any degree pr duce no important general symptoms, although even after the the temperature may fall. In large burns, even of the first degre the symptoms are often intense.

Immediately following a severe or extensive burn the temper ture is subnormal, but may rise considerably above normal shortl before death. Rectal temperature in cases of severe burns ofte registers several (3 to 4) degrees higher than the axillary. Co lapse or shock, in varying intensity, is usually a dominant cha acteristic in severe burns; it is not uniform. The temperature i subnormal, the skin is pale and cold, the pulse rapid, and th mind apathetic. The patient may vomit, and often complain of thirst. If vomiting occurs shortly after a severe burn, it si nifies an unfavorable prognosis. The urine is scanty and ma contain hemoglobin; even in mild burns the urine is found to co tain albumoses as the case progresses. In fatal burns the condition grows gradually or rapidly worse, the apathetic condition is replaced by delirium and convulsions (clonic), the skin is cyanosed, diarrhea and vomiting occur, and coma and collapse follow.

Occasionally shock does not appear as a symptom even of fatal burns. but the temperature rises above normal, the patient is restless, excited, and complains of the pain he suffers. This is followed by exhaustion and coma a short while before death.

Prognosis.—Of whatever degree it may be, a burn covering two-thirds of the body surface almost certainly results in death; a burn of half the skin surface probably causes death; and a burn of one-third of the body surfaces very frequently kills. It is an established fact that immediately, and for some time continuously, after a burn there appear in the blood undetermined toxic agents which play an important rôle in the production of the general pathologic changes and death. Another frequent cause of death is shock. A third factor to which the cause of death is attributable is the loss of plasma from the blood in burns of the second degree. Burns are unquestionably more serious in the young, the old, the feeble, and delicate, and in alcoholics, the latter being more susceptible to lesions of the viscera. Death may result from a complicating duodenal ulcer. Burns of the chest and abdomen are more serious than those of the remaining parts of the body. Naturally, burns of the pharynx and larynx are exceedingly grave.

In those burns not of themselves necessarily fatal the most frequent cause of death unquestionably is infection. Naturally it does not concern us in burns of the first degree, but in all others it is of the greatest interest.

It is safe to say that all second degree burns heal without scar-formation, unless infection has occurred and destroyed the surface of the skin proper. The redness resulting from such burns disappears in a few months. It is likewise important to inform the patient who has a third degree burn that healing will necessarily result in cicatrization and possibly an exceedingly ugly deformity.

Treatment.—The treatment of burns may be subdivided into the treatment of the general condition and the treatment of the burn itself. The former, naturally, is necessary only when the lesion is of sufficient intensity to produce a marked constitutional impression or when anodynes are necessary for relief of pain. Shock is to be combated here, according to the rules already laid down, and in those cases which suffer the loss of large quantities of fluids from the blood it is essential to maintain the proper consistency of the blood by continued administration of fluids by mouth, by rectum, subcutaneously, or intravenously.

The local treatment of burns may be summed up in the brief statement: prevent infection and control pain. It may be added that the accomplishment of the former is the most rapid and sure plan of alleviating and preventing the latter. The plans heretofore in vogue of applying various lotions and ointments, many of which are not sterile, have only added insult to injury. Those which contain toxic drugs, as carbolic acid, mercury, and iodin, or drugs which may liberate iodin are positively contra-indicated in large burns, and those which are not toxic, such as carron oil and picric acid, while they represent an improvement over the first-named group, demonstrably do not give the best results.

Burns of the first degree are to be treated by making such applications as will exclude the air. Simple dry dressings, with or without the use of dusting-powders, moist dressings of saline solution, boric acid, or, if the burns are not large, the application of a 1 per cent. solution of carbolic acid (see Gangrene). The advantage gained by the employment of carbolic acid is its anodyne effect upon the nerve endings. Ointments or oily solutions may likewise be employed in these burns. Vaselin, boric acid, or zinc oxid ointment are probably as good as any. The important fact to be remembered in these cases is protection from the atmosphere, and any plan that accomplishes this end satisfactorily is good. The body of the patient may, in extensive burns of the first degree, be placed in a warm bath of saline solution or a weak solution of sodium bicarbonate; this relieves the pain, and may be kept up continuously for any necessary length of time.

Sunburn may be prevented by the application of vaselin or ointments before exposure.

Burns of the second degree and of the third degree are open wounds, which universally become infected soon after their occurrence, and must consequently be dealt with accordingly. The most important feature of the local treatment of these burns is the prevention of infection. This can be done only by a rigid, tedious, and often protracted process of preparation of the surface. Of course, if the burn is small it may be sterilized by the application of tincture of iodin, 2 to 7 per cent.; if it is large, one dares not employ it. If the patient is a child, or if the burn is extensive and not necessarily fatal, a general anesthetic should be administered, and the whole burned area be scrubbed with sterile water, sterile soap, and a sterile soft brush or sponge until it is clean. All foreign particles and shreds of tissue that are loose should be removed; the surface should then be washed with ether or alcohol and rinsed with saline; blebs should be punctured near the edge and their contents allowed to escape, but the cuticle should not be removed. When the surface has now been entirely dried, the dressings are applied dry and allowed to remain *in situ* for a week or more, unless the general or local condition demands their removal. To prevent sticking of the dressing to the wound surface sterilized vaselin, or, as I believe to be more valuable, a sterile paste of bismuth, 20 to 30 per cent. in vaselin, may be applied. Burns of the second degree are healed when the dressing is removed in seven to ten days and the eschar of third-degree burns is ready to come away. If infection occurs, the plan of treatment is the same as that indicated in the chapters on Inflammation and Ulceration. The large granulation surfaces of third degree burns must be skin-grafted *pro re nata*.

The best plan of treatment for electric burns, which under the usual plans heal exceedingly slowly, is to dissect the burned tissue away and suture with the hope of primary union.

The treatment of *x*-ray and radium burns is the same as that of ordinary burns of the same degree.

CHAPTER XXIV.

FROST-BITE, FREEZING, AND CHILBLAINS

THESE lesions all result from exposure to low degrees of cold sufficiently long to kill or cripple the tissues. The degree of cold and the time of exposure required to produce frost-bite or freezing varies very much with the condition of the individual and with the habits of the people; those who live in mild southern climates are much more easily affected than those who have been reared in cold climates; the weak, anemic and thin, the very young and the old are, as a rule, more susceptible than the robust and vigorous. However, people who show the same apparent vigor vary very much in their resistance to cold, due to idiosyncrasies which are not understood. Manifestly, cold affects the body much more rapidly if at rest than when muscular activity is continued. It is, therefore, important that individuals who are exposed to cold shall continue to move, and not yield to the temptation to lie down and sleep, a tendency sure to appear when the body begins to be very cold. Cold is more apt to affect the exposed parts of the body, naturally, and those portions in which the activity of the circulation is interfered with by pressure. The hands, the feet, the nose, and ears are most frequently affected.

Pathology.—The first effect of cold is to produce contraction of the arterioles, producing temporary anemia. This is followed by passive dilatation and transudation of serum, which causes blebs to form. As the cold is prolonged, the tissues and the blood freeze and the blood-corpuscles are destroyed, liberating their hemoglobin.

Frost-bites are described in three degrees, corresponding very well in the extent of injury with the three degrees of burns.

First Degree.—This is the mildest form of frost-bite, and, when the tissues are thawed, results in redness (often bluish) and swelling, due to paresis of the smaller blood-vessels. The discoloration and swelling may persist for a week or more and gradually disappear, although a permanent dilation may result and remain indefinitely.

When the exposure to cold is prolonged or frequently repeated, especially in anemic and chlorotic individuals, a persistent or recurrent and uncomfortable lesion, known as chilblain or pernio, occurs. Chilblains, or perniones, appear most frequently on those parts usually affected by frost-bite, namely, the hands, feet, nose and ears, and rarely the penis. They are most common on the heel and external margin of the foot. They are purplish or reddish-purple patches, elevated somewhat above the surrounding normal skin and presenting a glossy surface. Vesication and ulceration may appear on the surface of the chilblain.

The patient complains of, and may be sorely tormented by, the itching or burning sensation present, which is frequently intensified by increasing the temperature of the surface, and is only rendered worse by scratching or rubbing. During the warmer seasons chilblains disappear, but return with each winter, and may continue indefinitely.

Second Degree.—In frost-bites of the second degree the tissues have suffered still more intensely. When thawing occurs the skin becomes dark or red or purple in hue, and swelling occurs. The more rapidly the part is thawed, the more intense the color and the greater the swelling, provided the tissues are lax. Blebs, which may be very large, form, and are filled either with a turbid or a clear fluid. Associated with these, as in the case of burns, are frost-bites of the first degree. Healing occurs under a scab, after rupture of the blebs, without cicatrization. Perniones may result from frost-bites of the second degree; at any rate, tissues so affected are less resistant afterward, especially to cold. Ulceration may result from these frost-bites and heal necessarily with scar formation.

Third Degree.—In this degree the surface may be covered with blebs or mottled blue and white and mortification occurs in varying depths. When thawing occurs there is no reaction, no swelling, no redness; only the bluish color, and possibly the formations of blebs; when the latter dry they leave the surface covered with brown crusts. The nails, the fragments of skin, the scabs, and the dead tissues later come away, and leave ulcers which may be hyposensitive or hypersensitive and run an unhealthy course. If the deep structures are frozen gangrene results and a line of demarcation forms. The surface surrounding the dead tissues frequently becomes a bright red color.

Fourth Degree.—Fourth degree frost-bites are sometimes described, and embrace those cases in which an entire extremity is frozen.

Symptoms.—The local symptoms experienced on exposure to cold are burning, smarting, or tingling of the parts, and this may be followed by pain more or less severe. As the freezing advances the pain may subside and the tingling and burning cease, owing to the anesthetic action of cold on the cutaneous nerve supply, and further progress of the case may produce but insignificant discomfort.

In general freezing, as the body grows colder intense rigors appear and continue. There is an irresistible tendency to sleep as the lassitude increases, and, unless the individual can continue to move and overcome his inclination to lie down and sleep, death is sure to follow. The temperature of the body is gradually reduced until it reaches very low points. Following restoration of the body to a warmer atmosphere the temperature gradually rises, often to several degrees above normal (104° F.).

Prognosis.—The outcome of cases of freezing of the first and the second degree is very favorable. Chilblains may result from either and ulcers from the second degree frost-bites. In frost-bites of the third degree there is more or less destruction of tissue, but the extent of damage cannot be estimated until a line of demarcation develops. In general freezing recovery has been recorded after the rectal temperature had reached as low a mark as 75.2° F., but the majority of such doubtless die, and many die whose rectal temperature has not been reduced to 90° F. The reaction of the patient and the rise of his temperature to normal are not positive proof of ultimate recovery. Death may occur several days after such an occurrence. In general freezing the prognosis is very bad, and, if life is saved, there is sure to be severe loss of parts.

Treatment.—When frost-bitten patients are discovered, it matters not of what degree, the most important thing to know is that the part must be restored to normal temperature by slow processes; the more intense the freezing and the more general, the slower the restoration, even if it requires several hours; and that introducing the patient into a warm room or the application of warm substances is certain to prove harmful. The frozen parts should be rubbed with snow or shaved ice, and, as reaction begins to be established, the temperature of the room can be raised very slowly to a comfortable point, and the snow or ice replaced with cold water. As the circulation is reëstablished the pain, tingling, and burning may reappear, or, even in frost-bites of the first degree, the skin may remain insensitive for several days.

The parts that have been frozen should be protected from heat and irritation, and often require the application of cold, in the form of lotions or otherwise.

If discoloration and swelling tend to become chronic, massage, artificial active hyperemia, and bandaging should be employed.

In frost-bites of the second and the third degree every precaution should be taken to prevent infection, according to the rules laid down in the treatment of burns. Surfaces whose epithelium has been destroyed should be covered with sterile bland ointments, to prevent adherence of the dressing.

When a line of demarcation forms, removal of the gangrenous tissue must be done according to the demands of the case.

Chilblains are to be treated by stimulating applications, as iodin in one of its forms, active hyperemia, protection from irritation, pressure and extremes of temperature; but, very especially, by correction of the general condition which predisposed to them.

CHAPTER XXV

FRACTURES

A FRACTURE is the solution of continuity of bone or cartilage by sudden violence. A fracture is a break of either bone or cartilage.

Cause.—The etiology of fracture is subdivided into predisposing, or pathologic, and exciting, or mechanical, causes.

The factors which favor the production of fractures are those which of themselves reduce the resistance of the bone to strains. Hence, any pathologic condition which, like rickets, tends to prevent the deposit of a sufficient quantity of calcareous material in the bones leaves them weaker than normal; any condition which, like malignant tumors, primary or secondary, reduces the strength of the bone by absorption or permeates it with fleshy material or thins out its walls until they are mere shells by growing in the medullary canal favors fracture; any disease or condition which diminishes the connective-tissue content, as osteomyelitis, or relatively increases the earthy material, thereby increases the fragility of the bone and favors fracture. A pathologic fracture is one which has been made possible by pathologic processes affecting the bone, and occurs under circumstances of normal function. It is manifest, too, that such processes, when not sufficient to cause fracture within the limits of ordinary bodily exercise, render the bones more susceptible to traumatisms. Atrophy from disuse always weakens the bones.

The exciting or mechanical cause of fracture is a force applied to the structure concerned. The cause may be direct or indirect; it may be due to the muscular effort of the individual, to a purely extraneous force, or to the two combined. A direct fracture is one produced at the point of application of the causative force. An indirect fracture is one produced at some other point than the point of its application. It may be assumed, for practical purposes, that in direct fractures the external force is the sole cause of fracture. In indirect fractures the external force may or may not be the sole cause; it is frequently supplemented by muscular contraction of the part. Occasionally, in both health and disease—*e. g.*, tetanus—fractures occur in healthy bones as the result of muscular contraction alone. The site of fracture from indirect causes is determined by the point of least resistance in the bone, and by the level at which the greatest strain is produced by the forces which serve to produce the fracture. It does not occur at either of these points, but between them.

When a fracture is produced there occurs not only severance of the osseous tissue and the soft structures encased within it, but the periosteum almost invariably, and the surrounding soft structures frequently, especially if they are closely attached to it, are more or less extensively torn: the periosteum is at times stripped up some distance from the point of fracture. While the periosteum surrounding the fracture may be completely severed, there is usually a part of its circumference, the side of the smaller angle, that escapes rupture, which is known as the periosteal bridge. More or less bleeding takes place from the severed vessels, and the blood accumulates between and around the severed ends of bone and may escape for some distance into the surrounding connective tissue.

Types of Fracture.—A *simple* fracture is one in which the injury to the soft parts is little or no greater than the possibility of fracture demands, and in which no important structure other than the bone is injured.

A *compound* fracture is one in which a wound is produced leading from a mucous or cutaneous surface to the fracture. It is not compound so long as there is no such communication, although the wound and the fracture may both exist as the result of the same injury. The trauma producing the fracture may be the cause of the wound, as in a kick by a horse where the shoe cuts down to the bone and breaks it. The wound may be the result of the fractured fragments perforating the soft parts from within outward; this is the usual cause of fractures being compound when produced by indirect force. The wound may likewise be produced by the close attachment of the soft parts to the periosteum; this type is common in fractures of the body of the lower jaw, where it is rare for a fracture to occur without rupturing the closely attached mucoperiosteum. Gunshot fractures, in the very nature of the case, are usually compound, especially if produced by discharges from small arms.

A *complicated* fracture is one in which some other important structure is injured, such as the rupture of important muscles, tendons, arteries or nerves, or the association of a luxation, or the puncture of a lung by the fragments of a broken rib.

A *single* fracture is the fracture of a bone at one point.

A *double* fracture is a fracture of a *single* bone at two points.

A *multiple* fracture is a fracture of a bone at more than two points. The lines of fracture do not communicate.

A *comminuted* fracture is one in which the bone is crushed or broken into small fragments. Here the planes of fracture communicate with each other. In thin or flat bones such a fracture is sometimes spoken of as egg-shell fracture.

A *unilateral* fracture is a fracture of one side of a median bone for example, the mandible, while a *bilateral* fracture is a break of th median bone on each side of the median line.

The terms *transverse, oblique,* and *longitudinal* are sufficient clear to require no definition. They refer to fractures of lo bones, as a rule. A *spiral* fracture is one in which the line of fr ture runs in a more or less perfect spiral around the circumferen of the bone and is produced by a twisting force. *Longitudin* fractures frequently are only fissures.

A *serrated* fracture is one in which the fractured ends are irre ularly jagged.

A *denticulated* fracture is one in which a long sliver remai attached to one fragment while it is split up from the other. Th fracture and very oblique fractures are especially likely to be compound if there is great angular displacement at the time of occurrence.

A *depressed* fracture is one in which the bone is driven perceptibly into the cavity the bone forms. This term applies especially to fracture of the ribs and of the cranial bones.

An *impacted* fracture is one in which the fragments are drive immovably together after fracture occurs, as is observed in thos cases where the shaft of a long bone is forced into the spongy head Manifestly those signs dependent upon the mobility of the fragments relative to each other are wanting here.

Besides the above, representing the complete fractures, are th *incomplete* fractures, which embrace *green-stick* fractures, *fissures* and certain depressions of bone, as, for example, in the cranium when the outer table is driven down upon the inner. *Incomplet* fracture simply means that the fragments remain more or les firmly bound in their original position and are in no case sufficiently broken to allow removal of a fragment without furthe breaking. *Green-stick* fractures occur in those whose bones hav not yet fully ossified, hence in the young. The term is aptly applied, for, as in breaking a green stick, the fibers on the convex surface break, while those on the concave surface only bend.

Fissures are fractures in which, although the bone may b separated partially or completely, there was not sufficient displacement to rupture the periosteal covering extensively. Originall thought to be rare, they are now known, thanks to radiography, t be much more common.

Epiphyseal separation, while not exactly embraced in the definition of fracture, practically belongs to the group. There is no break of osseous tissue here, but a separation of the epiphysis from the diaphysis. They are, of course, transverse, and have this disadvantage over fractures, namely, that after healing the epiphysis becomes ossified and further growth of this bone in length from the affected epiphysis becomes impossible; an important fact to remember in rendering a prognosis.

Signs and Symptoms of Fracture.—There are three classic signs of fracture, the unmistakable presence of any one of which makes a positive diagnosis. Unfortunately, we have learned that a large number of fractures show neither of these signs, and there a still greater number in which, though they might be discovered, their demonstration is positively harmful. Going a step further, one may say that so soon as sufficient evidence is at hand to make a diagnosis all further manipulation should be abandoned.

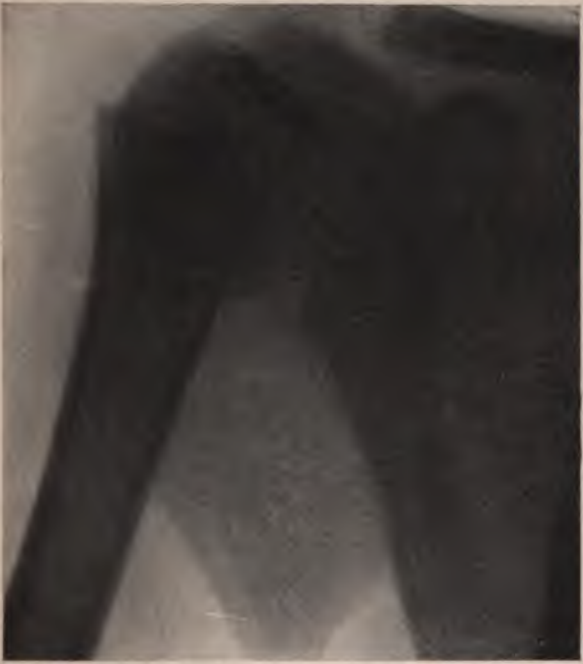


Fig. 77.—Skiagraph of a simple fracture of surgical neck of the humerus.

These three signs are crepitus, preternatural mobility, and spontaneous displacement. By crepitus is meant the vibrations, heard or felt, produced by the movement of the fragments on each other. It may be fine enough to be called crepitus in its proper meaning or coarse enough to feel and sound like a distinct knock, and may be distinctly felt by the patient himself. In cases where the fractured surfaces are not in contact, where the fracture is incomplete, where the fragments are prevented from moving by the nature of the fracture—*e. g.*, in impacted fracture, or where they are held in position by surrounding structures—crepitus cannot be elicited, or, if so, only by production of positive harm. Bones covered by a large thickness of tissue reveal crepitus less plainly than more superficial ones. It must be borne in mind that crepitus is transmitted readily along the whole length of a fragment, and hence is often a poor sign of itself to locate the exact point of fracture, although it is not so readily transmitted across a joint from one bone to another. Crepitus is elicited only by manipulation of the part or by attempts on the part of the patient to move it; such motion or manipulation may in certain fractures be of little harm, but in others it is baneful on account of the increased laceration of soft parts and increased hemorrhage and swelling following it. Besides, it is universally painful, except in certain pathologic fractures.

Preternatural, or Unnatural Mobility.—This signifies that mobility is found at some point in the course of a bone, where no motion would be found if the bone were intact. It is a most important sign when discoverable without undue traumatism. It is most easily discoverable in the shafts of long bones, more difficult when the fracture is near a joint; in such cases unnatural mobility may be demonstrated more satisfactorily by attempting movements in directions or to a degree not permitted by the normal range and direction of action. In impacted fractures this sign is altogether wanting, unless the impaction is released by manipulation, and it is partial or wanting in incomplete fractures and in most fissures.

Spontaneous Displacement.—When a bone is broken it usually fails to render its normal support or to stand its normal strain. Hence, when the part affected attempts to functionate deformity is produced by muscular action or by the weight of the part. If the part is placed again into its normal position and left alone, it is readily displaced by its own weight or by muscular contraction when the supports are removed. It is superfluous to say that spontaneous displacement is absent in impacted fractures which maintain the position determined by impaction, however abnormal that position may be. It is wanting, too, in most fissures and incomplete fractures, and so slight in those densely covered by connective or muscular tissue as to be discovered only with difficulty. If the palpating finger is placed on the site of suspected fracture and motion, active or passive, is attempted the fragments may be felt to move, and this demonstrates unnatural mobility and perhaps spontaneous displacement.

Deformity.—Often this sign alone is sufficient to insure a diagnosis of fracture; when, as is often the case, the deformity is extreme no doubt is left; if it is slight, it must be taken only as suggestive, unless it be in a direction that eliminates the possibility of error. Deformity is less valuable when in the region of a joint, as it might signify either fracture, luxation, or contusion. One must be assured, too, that the existing deformity resulted from the injury, for malingerers sometimes claim that a pre-existing deformity resulted from a recent injury. The deformity may, in long bones, be either in the nature of a deviation from the normal course, as indicated by the corresponding member of the opposite side of the body, or appear as shortening, or, especially in case of bones enclosing a cavity, as a depression. If a large hematoma should form over the injured area it often gives one the impression that a depression in the bone exists when none is present, or, on the other hand, that no depression of bone is present when a dangerous and extensive depression exists. Deformity may exist in such slight degree as to escape all the coarser methods of diagnosis, and yet be demonstrated by making an incision down to the bone, as in cranial fractures, or by skiagraphy.

Pain.—Pain of itself is not satisfactory evidence of fracture, but the nature of the pain may be sufficiently important to justify a diagnosis of fracture. If pain is present, or is produced by pressure at the site of injury, it signifies only damage to the tissues. If it is produced by remote manipulations of the bone, so directed as to move it at the injured spot, it indicates probable fracture. For example, a man receives a blow on his chest. A bruise is produced; pressure on the suspected rib some inches from the contusion should not produce pain unless fracture is present. So, in general, moderate motion of a bone not fractured, except in injuries of the joints, is not painful, but, if a fracture is present, either active or passive motion produces pain. Pain is often very suggestive in obscure cases when its severity is out of all proportion to the apparent injury done. The absence of pain also in cases of unmistakable fracture indicates that they are pathologic, probably syphilitic.

Skiagraphy.—The value of the skiagraph for diagnostic purposes is perhaps greater here than in any other field of surgery, and many injuries formerly suspected to affect only the soft parts are now shown to be fractures, demonstrating the fallibility of the above-named methods of diagnosis and increasing considerably the percentage of fractures relative to injuries in general. Furthermore, skiagraphs show considerable displacement of fragments when no such evidence appears from a manual examination, and even when the best and formerly most satisfactory reduction has been made. If a fracture is present and a good picture can be made, its presence may be perfectly demonstrated; but, if the epiphysis has not already ossified, it is best to make skiagraphs of both the normal and the diseased side for comparison. In the simpler cases of fracture the examination may be done with moderate satisfaction with the fluoroscope; it is much better, however, to study the negative.

Ecchymosis and Blebs.—In any fracture more or less ecchymosis may be produced, and, as in other deep injuries, the discoloration may not appear until some days subsequently, and then be some distance from the level of the fracture. So, too, in the larger fractures large blebs may appear under the cuticle within a few days after receipt of the injury.

Prognosis of Fractures.—As a rule, the outcome of fractures is very gratifying. The life of an individual is rarely jeopardized, except when associated injuries are received and when the fracture is in a very dangerous region, and in cases of compound fracture, where, of course, the fracture plays a minor, and infection a major, part. The fracture itself heals in the vast majority of instances, often in spite of adverse conditions, chief of which is imperfect reduction.

Treatment.—Two items constitute the treatment of simple fractures, namely, reduction and immobilization.

Reduction.—By reduction is meant replacement of the bony fragments into their normal position. It is ordinarily attempted by the employment of *extension, counterextension*, and *manipulation*. Although this plan is the one commonly employed, and one that will remain the method of choice in the hands of the average practitioner, and, indeed, in all hands, except in special cases of fracture or under special circumstances, one must admit that skiagraphy shows almost invariably failure of perfect reduction even in the most satisfactory cases. Yet the results have been such as to warrant the continuance of the method as a routine in general practice in preference to the open method. By the term *extension* is meant the traction made by the surgeon to overcome the displacement due to contraction of the muscles. It is applied to the distal fragment. By *counterextension* is meant the resistance against which traction is made; it may be simply the weight of the body, or this plus traction made on the proximal fragment by an assistant or by the surgeon himself in the direction opposite to that of extension. Extension means a pull on the distal fragment away from the body; counterextension means a pull on the proximal fragment toward the body. For evident reasons, extension and counterextension are useful chiefly, if not only, in the extremities. In certain cases—*e. g.*, fracture of the olecranon or the patella—the two fragments must be drawn together, reversing the usual application of extension and counterextension.

Manipulation.—By manipulation is meant such manual changes in the position of the fragments as will force them into their proper places. Manipulation is often necessary, in conjunction with extension and counterextension, in reducing fractures of the extremities; while in most other fractures reducible by bloodless methods, manipulation is the sole plan for reduction. The manipulation necessarily varies with the fracture. In one instance a rotation right and left is sufficient, in another distinct pressure and alignment must be done by the manipulating hand, and in yet another the fragments must be lifted into position by various mechanical aids, as in reduction of comminuted fracture of the nose by insertion of a probe into the nostrils, or the lifting of a fractured zygoma by passing a large curved needle beneath it, with which it is lifted back into position.

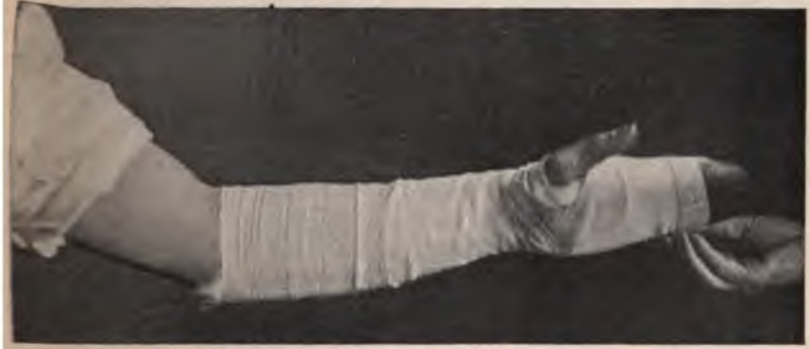


Fig. 78.—Fractured forearm immobilized by metal splint.

Immobilization.—After a fracture is properly reduced it must be held in proper position by mechanical supports until union shall have occurred. This maintenance of position is known as immobilization. It is accomplished by the employment of any mechanical appliance demanded by the case in hand. It is usually done by splints or by plaster-of-Paris casts, with a proper padding of the part, giving especial attention to bony prominences to avoid pressure necrosis and ulcers. The splints or cast should fit the part snugly, and should be applied only tightly enough to hold the fragments in reduction. It is wise in using plaster casts not to apply them until swelling has had time to come up and subside, as the swelling will cause the cast applied early to become too tight and endanger the circulation, and its subsidence will leave the cast applied during the height of swelling, to become too loose and fail of its purpose. All fracture dressings should be inspected several times during the first forty-eight hours after application, and the toes or fingers must be left free, as swelling or discoloration of them would suggest too tight a dressing. In many cases splints can be dispensed with to advantage and some part of the body used to serve a similar but better purpose; for example, the humerus, when fractured, may be immobilized against the chest, or the fragments of a fractured elbow by sharp flexion of the joint (Jones).

I have already stated that the object of immobilization is to hold the fragments in correct position. This is frequently impossible, even when reduction can be done, owing to the continual traction of large muscles. It is especially difficult in fractures of the femur of muscular subjects. Hence extension is often necessarily continued through a part or the whole period of treatment. It is made by the method of Buck, or by various plans which combine the features of immobilization and traction in the same apparatus.

If, for any reason, the immobilizing apparatus becomes too lax it must be changed and refitted. If the fracture is compound the usual requirements of wound dressing will determine the frequency of change. If plaster casts are used in compound fractures a window may be cut over the wound to allow dressing.

The treatment, in general, of compound fractures is that of wound plus fracture. It is perhaps wiser to employ the open method in compound fractures if seen early, as no great additional risk is entailed thereby.

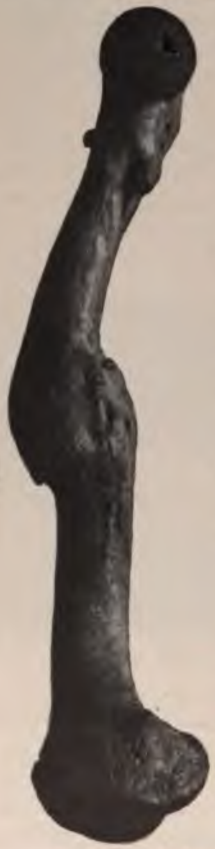


Fig. 79.—Vicious union of fractured femur, showing both deformity and great shortening.

The time required for immobilization varies not only with the fracture, but with the age of the patient. Compound fractures unite more slowly than simple; fractures in the young unite earlier than in the old; those of small or thin bones sooner than in large or heavy bones. Two weeks is about the minimum limit of treatment, and eight to ten weeks may be required.

False Union and Vicious Union.—In case insufficient callus is formed, or if ossification fails, the ends of the fragments may become united by fibrous tissue, constituting a *pseudarthrosis.* Vicious union is union of the fragments in unnatural position; this often produces the most bizarre deformities.

Delayed Union and Ununited Fracture.—The term "delayed union" is employed to signify that union has failed to occur within the usual time required for repair of the given fracture. But union is not impossible, and the reparative process has not finished its work. Ununited fracture is employed to signify that the healing process, after doing its utmost and having finished, has failed to produce union.

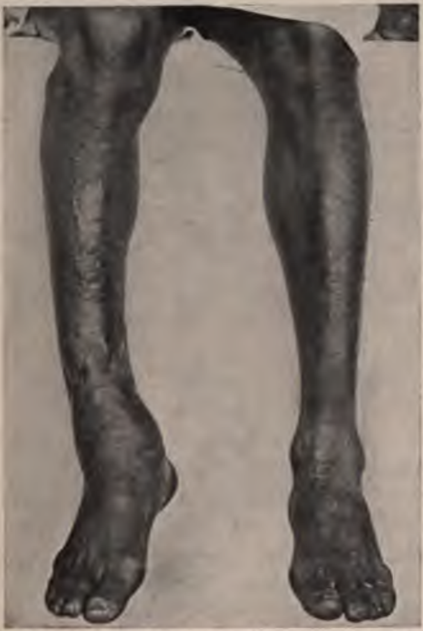


Fig. 80.—Ununited fracture of lower fourth of right tibia and fibula.

It is impossible to draw a distinct line between delayed union and ununited fracture except by convention. Ordinarily we speak of a fracture that fails to unite in the normal period or a few weeks longer as delayed union; if several months have elapsed, it is spoken of as ununited fracture. Granulation tissue is still present in delayed union; in ununited fracture the whole mass of new tissue has cicatrized, or, which is to the same purpose, ossified.

The causes of these two conditions—the second is but a later stage of the first—is an interference, locally or constitutionally, with the nutrition of the osseous tissues or of the osteoblastic cells, imperfect coaptation, so that the fractured ends may each become covered with an osseous callus, but the two are found out of contact, and, therefore, without union, or last the interposition of some tissue or foreign substance between the ends of the fragments that serves to separate them. The causes in detail are: improper nourishment of the body prior to or after the occurrence of fracture; this may be due to disease or improper diet; disease of the fractured bone; this disease may come up as a consequence of the fracture, especially if compound, or may have been present heretofore. Pathologic fractures are notoriously likely not to heal. Pregnancy, while not a pathologic condition, favors delayed union in fractures received during its progress. Interference with the local nutrition, as produced by the too tight application of dressings, or by the prolonged application of cold, is causative of these conditions. Imperfect immobilization, imperfect reduction, and the interposition of foreign bodies or fragments of tissue, commonly bone, periosteum, muscle, fat, or fascia, are by far the most frequent local causes of delayed union. Infection invariably delays the healing process and may result in failure of union. The frequency of delayed union in compound fractures is thus explained, and the treatment of fractures should be prolonged on occasions of this kind.

Treatment of Delayed Union and Ununited Fracture.—The first item in treatment is to determine the cause of the failure and correct it. A thorough investigation will rarely fail to show what the cause is, but frequently it is impossible, as in cases of pregnancy and in pathologic fractures, especially if due to metastases from malignant tumors, to remove the cause. Certain pathologic cases are manifestly hopeless. If no foreign body is interposed between the fragments, and if no local pathologic process aside from the traumatism is present, the diet may be corrected, proper adjustments of splints may be made, and the fragments may be incited to further effort by vigorously grinding or manipulating the fragments against each other while the patient is anesthetized. If diet, splints, rest, and proper reduction fail, especially if they fail after a second attempt, further tentative treatment should not be employed; incise, remove the cause, adjust accurately, and hold in position by Lane's plates, screws, pegs, wire, bone, or catgut. This should be the plan in all ununited fractures; the others mentioned are a waste of time.

Treatment of Fractures by the Open Method.—Of recent years, thanks largely to the work of Mr. Arbuthnot Lane, of London, the treatment of fracture by the open plan is growing rapidly in favor. Personally, I believe that where the work can be done under proper environment it is much preferable to the bloodless plan in the majority of serious fractures, for by it the fracture can be reduced under ocular inspection, and can be immovably fixed in reduction; pain due to subsequent movement of fragments is eliminated, deformity and shortening do not occur, and the time of union is materially shortened. It is the method of choice in fractures of the larger bones, and can be done easily and safely by any one acquainted with his anatomy and with aseptic methods. Infection must be guarded against absolutely. The material employed to unite the fragments if metallic, as Lane recommends, should be proof against corrosion in the tissues.

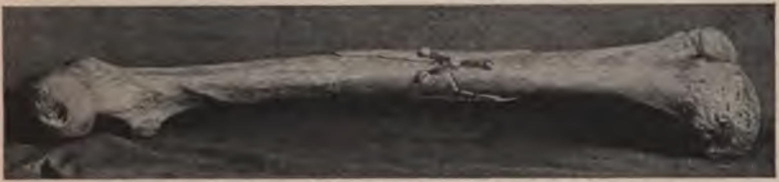


Fig. 81.—Fractured bone immobilized by Lane's plate.

CHAPTER XXVI

LUXATIONS OR DISLOCATIONS

A LUXATION, or dislocation, is the displacement of one or more bones of an articulation from the normal relation to the remaining bones which go to constitute the articulation.

Luxations may be partial or complete. In the former the displaced articular surface is not completely removed from its fellow; in the latter it is.

Classification.—The classification of luxations is as follows: *Simple* luxation is one in which there is no further traumatism done than that necessary to permit the dislocation. Compound dislocation is one associated with a wound leading to the joint surface or through which the dislocated bone protrudes. A *complicated* dislocation is one associated with another important lesion in the same region. A *unilateral* dislocation is a dislocation of a median bone on one side; a *bilateral* dislocation is the dislocation of a median bone on both sides.

Cause.—The production of luxations, like fractures, is largely traumatic, the force being applied in such a manner as to cause a desertion of one articular surface by another. The traumatism may be solely an extraneous force, solely muscular effort, or the two combined. There are certain positions of the elements of a joint and directions of force which favor the production of dislocation, owing to the structure of the joint. Hence, for each joint there are certain possible dislocations, some of which are much more frequent than others. For example, dislocation of the head of the humerus is usually forward, under the outer end of the clavicle.

Besides the above given causes, pathologic processes which render the ligamentous or muscular support of a joint less efficient favor dislocation. A frequent example is luxation of the hip-joint from insignificant force in children who have suffered from typhoid fever. Occasionally dislocations occur in the unborn fetus. Their causation is not clear.

In simple luxations the damage done is comparatively slight. The capsule and the ligaments are more or less lacerated, but the articular surfaces are not impaired. While dislocations affect bones, the real damage done is usually to the soft structures only.

Diagnosis.—As in fractures there have been three time-honored diagnostic signs, so in dislocations there are three, namely, absence of crepitus, preternatural immobility, and absence of tendency for the displacement to recur after reduction, *i. e.*, absence of spontaneous displacement. It is easy to understand that the difference between the symptoms of dislocations and of fractures, therefore, depends on the nature of the lesion and on the structures affected by it. In addition to the above symptoms, deformity is almost invariably the rule, and if the deformity is not present it is represented by the assumption of some particular attitude by the joint affected, and the maintenance of this attitude in spite of efforts, either actively or passively, to correct it. To determine whether deformity is present in a joint as the result of traumatism, it is wiser always to compare it with the corresponding joint of the opposite side. In many cases such comparison will render diagnosis certain from inspection alone. However, it is often necessary to measure the parts on the two sides of the body, by which means we are enabled to determine whether the injury has caused lengthening or shortening. The preternatural immobility produced in dislocation is due not only to the fact that one articular surface has partially or completely deserted its fellow, but to the further fact that the moment such desertion occurs the range of movement is materially limited by rigidity of the muscles which move the joint. In addition to the above-named signs of dislocation pain is a constant and frequently a very important sign. As in fractures, this pain is increased by attempted movements, but not to the same degree. By virtue of the fact that one bone has been displaced from another, a certain amount of injury is necessarily done to the soft parts, consequently, swelling is almost invariably present in dislocation, and occasionally it is extreme. It usually requires several hours for the swelling to reach its maximum, an important fact to be remembered relative to the time best suited to examination and reduction. Discoloration of the skin surrounding the joint and for some distance below it frequently is observed, due to the escape of blood into the subcutaneous tissues.

One frequently finds cases of ancient luxation, and occasionally a recent luxation, which has been mistakenly diagnosed all other kinds of lesions capable of affecting the joint. They are diagnosed as synovitis, arthritis, and especially as rheumatism—mistakes which, if the history of the case is taken into consideration and if a thorough examination of the part is made, should occur far less frequently than they do. In cases where there is doubt in the physician's mind, it can very easily be dispelled by a satisfactory skiagraph, which embraces not only the joint affected, but its fellow on the opposite side.

The most confusing lesion from which luxations have to be distinguished are fractures close to the joint, such as occur in the surgical neck of the humerus and in the neck of the femur. Epiphyseal separation is also very difficult to differentiate from dislocations.

Prognosis.—The results of proper treatment of dislocations is, on the whole, very satisfactory, much more so, in fact, than the treatment of fractures by the ordinary closed method. Failure, however, to reduce a dislocation within a reasonable time after its occurrence results in more or less complete loss of the joint, and may prove disastrous to the patient from an economic standpoint; for after a dislocation has occurred the joint surfaces may be more or less completely destroyed by the formation of new tissue over them, and the normal contour of the joint so altered that they will not fit each other even when reduction is made.

Recurrent Dislocations.—Certain dislocations are capable of recurring repeatedly, once they have been produced, even though the treatment at the time was satisfactory. This is due to the fact that the structures normally holding the joints in position have been so altered by the first injury that they are no longer capable of maintaining the bones in their relative position, and so allow dislocation to occur as a result of slight force or simply on movements of the joint to an extreme range. The joints in which recurrent luxations occur most frequently are the shoulder- and the temporomaxillary joints. When they do occur they are always of the same type as the original dislocation.

Treatment.—The object of treatment of a dislocation is to replace the bones in their normal position with as little additional damage to the surrounding structures as possible, and to maintain them in this position until the opening in the capsule through which dislocation occurred and the ligaments surrounding the joint may be adequately repaired. The rules for reduction of dislocations vary for the different joints affected, and, while extension and counterextension may be necessary, the chief factor in reduction is manipulation, which should be of such a nature as to place the bones constituting the joint in the relative position occupied by them at the time the dislocation occurred, and then to move them in a direction opposite to that taken by them during the displacement (Bigelow). Placing them in the position occupied at the time of dislocation relaxes the capsule and brings the articular surface opposite the rent through which it escaped. The movement of the bones in the direction opposite that of escape causes the dislocated one to return through the capsule to its normal position. Usually one may determine that a dislocation has been reduced by feeling a distinct knock of the bone as it slips back into place, and may satisfy one's self that reduction is accomplished by manipulation of the joint through its normal range of movement. Of course, the deformity disappears when reduction is accomplished, except such as results from swelling.

After reducing a dislocation the joint is to be restricted in motion and limited in use for a period of two to three weeks, and, if it is unnecessary to immobilize it, the patient should be cautioned against extreme ranges of movement for the same time.

Recurrent dislocations may be corrected by incision into the joint and correction of the lesion permitting it; ancient dislocations also frequently require to be corrected by opening the joint.

CHAPTER XXVII

THROMBOSIS AND EMBOLISM

THROMBOSIS

Definition.—The term "thrombosis" is used to signify coagulation of blood within the vessels during life. It is a very common pathologic process, and, produced as it is by pathologic conditions, by surgical procedures, and as a result of physiologic disturbance of the circulation or chemical alterations of the blood, it is a condition that concerns the surgeon very nearly.

Composition.—A thrombus may be made up of all the solid elements of the blood, due to coagulation and escape of the serum, or it may be made up of only a part of these elements, namely, the blood-platelets, white blood-cells, and fibrin, any one of which may predominate. The former produces primarily a red thrombus and occurs when the blood is stagnant, and the latter a white thrombus, which is the type produced while the blood is still circulating.

Causes.—The causes of thrombosis are very diversified, but fundamentally produce the condition as a consequence of certain changes common to them all. First, obstruction of the lumen of a vessel, be it vein or artery, will cause the appearance of a thrombus; it may extend from the site of obstruction to the lumen of the nearest branch leading from or into it, but in ligation of arteries is often found to appear only at the ligated point, if at all. Such thrombi are produced by ligation of blood-vessels in surgical work. Second, increase in the size of the blood-vessel, such as happens in varicose veins, favors production of thrombi. Third, infectious processes and traumatism, which interfere with the structure or the function of the intima, produces them. Fourth, they are favored by a circulation such as is found in very weakened individuals or in patients whose heart action is inadequate. Fifth, by general conditions, such as marasmus, chlorosis, hydremia. Thrombosis cannot occur unless there is some change in the blood itself or in the lining membrane of the vessel. All other factors are predisposing. The surgical conditions in which thrombi are most likely to appear are traumatism, whether operative or accidental, especially if it affects the blood-vessels themselves, infections, varices, and operations, particularly in the pelvis or lower abdomen, in patients whose vitality is much impaired. They are found particularly as a result of infection in regions well supplied with venous plexuses or in sinuses, such as the uterine and intracranial. If a thrombus forms in the lumen of a vessel through which the blood is still circulating it may be of the gray or white variety and arranged in concentric layers. Sometimes these layers are alternately red and white.

Symptoms.—Since thrombi may form in any vessel, whatever its size and importance, or lack of importance, it is easy to see that the symptomatology attendant upon thrombosis varies all the way from the most insignificant disturbances to the most violent. When thrombi occur in small unimportant vessels, no symptoms or signs appear; the same is true when they appear in larger vessels, provided there is an adequate collateral circulation. If thrombosis occurs in a terminal vessel, or in one which has no adequate collateral circulation, the most direful immediate and remote results may follow. But the symptoms even here are determined, not so much by the fact that a blood-vessel has been occluded, but because the circulation is shut off from an important structure or region. The particular region affected, too, gives color to the symptomatology; for example, thrombosis in the cerebral or dural vessels produces one group of symptoms, thrombosis of the mesenteric vessels another group, and they are determined by the fact that, in the first instance, brain tissue is disturbed, and, in the second, the alimentary tract. Thrombosis of an artery furnishing the main blood-supply to an extremity produces pain and pallor in the region whose blood-supply is cut off. If, however, the thrombosis occurs in a vein, swelling and cyanosis of the extremity are produced, giving us one type of phlegmasia alba dolens, or milk-leg, a condition formerly seen quite frequently as a consequence of unclean obstetric work. Whether the vein or artery of the extremity be obstructed, gangrene may result, as has been explained in the chapter devoted to that subject. In either instance the temperature of the part is materially reduced.

When thrombosis occurs in superficial veins or in the veins of extremities the veins may be felt as a hard cord, and are, in all probability, tender. If it is due to an infectious process signs of thrombophlebitis are present. In the hemorrhoidal plexus thromboses are quite a common occurrence, and may be found in patients who have had no hemorrhoids, but are more frequently found in patients who have a history of this condition, and are known as thrombotic hemorrhoids. Thrombotic hemorrhoids are capable of producing the most excruciating pain and are frequently very tender, being felt as firm, roundish tumors, situated either in the external or the internal hemorrhoidal plexus.

Though thrombosis may occur in any artery, vein, or even the capillaries of the circulation, and within the cavity of the heart, there are certain sites which afford the greatest number of instances. These sites are the veins of the lower extremity, especially the long saphenous and its radicles, which are frequently affected by the favoring condition of varicosis—the upper extremity is rarely affected—the rectum, the pelvic veins of women, the uterine sinuses, which are most frequently involved in connection with abortions or child-birth, especially if infection of the parturient canal has occurred, the cerebral vessels, and the dural sinuses. Occasionally the mesenteric artery or vein, usually the superior, is thrombosed, with resultant pains, distention, and gangrene of the intestines, attended with symptoms of a violent intra-abdominal disturbance and frequently with bloody discharge in the stools.

There are no constitutional symptoms attendant upon thrombosis, except such as depend upon the causative or resultant condition, as has already been shown. If infection be the cause, corresponding general symptoms of infection may be present. In those cases where thrombi appear in vessels necessary to the maintenance of life sudden death may occur. Thus, a ball thrombus may develop in the heart and suddenly block the auriculoventricular opening, and thrombi in the dural sinuses and the vessels of the brain may produce instantaneous death or paralysis.

Diagnosis.—Many thrombi appear and disappear with no symptoms or signs to give evidence of their existence. Such are continually attendant upon acute inflammatory processes, abscesses, and traumatism. Often the symptomatology may be obscure, but, if taken in connection with the presence of causes likely to produce thrombosis, may lead to a suspicion of the true nature of the lesion, particularly when the symptoms are referable to a region frequently affected by this condition.

Course of Thrombosis.—Manifestly, those thrombi which are produced by infection such as appear in thrombophlebitis and thrombo-arteritis are, other things being equal, most dangerous. This is true not only because the infection in and of itself is capable of causing an indefinite extension of the clot, but because they contain bacteria which may at any time reach the general circulation and produce pyemia.

Either infected or simple aseptic thrombi may originate in a small vessel of no importance, and, under favorable circumstances, gradually or rapidly extend into the lumen of the most important channels of circulation. So a thrombus may extend from the upper limit of the vena cava to the small radicles in the foot as one continuous clot, and thus interfere with the total return of blood from the lower half of the body.

One of the dangerous accidents resulting from thrombosis is liberation of a portion of the clot in the form of an embolus, which, by its lodgment in an important vessel, may produce sudden death or alarming symptoms. This accident is favored by active or passive motion or by massage or manipulation of the part in which the thrombus forms; it is favored, too, by allowing the patient to get out of bed and resume his active duties too early after operation, especially if the operation is done in the lower part of the abdomen or in the pelvis. Even the most insignificant intra-abdominal and pelvic operation, such as interval appendectomy or shortening of the round ligaments, has been known to result fatally from this source. The practical conclusion to be drawn from this is that patients should not be allowed to get up from such an operation short of ten days, except when the demands for such a course outweigh the chance of danger from this source. Thrombi do not become fixed until ten days after their formation, and, therefore, if the patient is allowed to exercise too early it will be an easy matter to dislodge the thrombi and produce blockage either of the right heart or of the pulmonary artery. Many sudden deaths from this source are recorded in the hospitals where postmortems are habitually held. These thrombi frequently form in the vessels of the side opposite the operation.

Soon after their formation within a blood-vessel thrombi may begin to organize by the outgrowth of new blood-vessels and fibroblasts from the lining cells of the vessels, following the same steps taken by the healing process under normal conditions. If the clot is red the hemoglobin gradually disappears from it and it becomes a whitish color, yellow, or grayish; finally, the whole thrombus is converted into cicatricial tissue and the lumen of the vessel obliterated, so that, instead of the normal vessel, only a fibrous cord is left as its representative. Occasionally after a process of this kind recanalization of the vessel occurs, which allows it to carry a part of its normal quantity of blood, although the lumen is permanently somewhat constricted.

Calcification may take place in thrombi and vein-stones, or phleboliths, be produced. These are seen rather frequently in the pelvic veins and in varicosis of the lower extremity. In the former situation they occasionally appear in skiagraphs, and lead to the mistaken diagnosis of ureteral calculi lodged in this position.

Disintegration of thrombi may occur as the result of fatty degeneration or from the peptonizing action of bacteria, and lead to the escape of the whole mass or a considerable part of it into the general circulation and lodgment of the particles in various parts of the body, and these emboli, if they are septic, establish pyemia.

Prognosis.—Presence of simple thrombi in the smaller unimportant arteries is of little consequence, but the presence of a thrombus in a vein carries with it necessarily always more or less risk to life or limb, and this danger increases with the size and importance of the vessel, and is at its worst when the cause is one of the pyogenic bacteria.

Treatment.—Prevention of thrombi should be accepted by the surgeon and the physician as a most imperative duty. In all cases the utmost care should be used in manipulating the tissues so as to prevent damage to the lining of the blood-vessels, especially in the dangerous regions. When it is possible the patient's general condition should be brought, by pre-operative treatment, as nearly to normal as possible, so that operation may be undertaken under the most favorable circumstances. Where this cannot be done prior to operation, all patients whose condition favors the appearance of thrombosis should be treated in such manner as to maintain their circulation as nearly normal as possible. It is superfluous to say that in all cases the utmost care should be used to prevent infection.

When thrombi have developed, the greatest care must be exercised not to allow anything to be done that could displace the thrombus as a whole or in parts, to maintain the circulation of the part as perfectly as possible, and to support the life of the part by elevation and the application of artificial heat until adequate collateral circulation can be established. Absolute rest in bed must be enforced upon these patients, and they should have an attendant to change their position, so as to avoid all physical effort.

If a thrombus is septic, or if it continues to spread, the vessel containing it should be ligated above and below the clot, and an incision made into the lumen of the vessel between these ligatures, the clot cleaned out, and drainage instituted. Complete hysterectomy may be necessary in septic thrombosis of the uterine arteries, and has, in fact, been recommended and practised by Trendelenburg in these cases to prevent general sepsis. If in a given case of thrombosis it is impossible to ligate the vessel on each side of the clot, as frequently happens in thrombophlebitis of the dural sinuses, it is necessary to open the vessel, clean out the infected clot, and control hemorrhage by tamponade.

The general nutrition of the patient must be carefully looked to, and an effort made by feeding, stimulation, and tonics to bring both the blood and the circulation to their normal standing.

EMBOLISM

An embolus is a foreign substance—solid, liquid, or gaseous—which is carried in the blood and lodges, producing a more or less complete occlusion of the vessel at the point of lodgment.

Emboli, of course, cannot form from substances which dissolve in the blood immediately on gaining access to the vessels. They must, therefore, be at the time undissolved in the blood. They are derived from two sources, namely, from within the blood-vessels, which are called endogenous, or from without the blood-vessels, which are called exogenous, emboli. Either of these two types may be *bland* or *active*. By a *bland* embolus is meant one which is incapable of doing harm to the tissues or the body aside from its mechanical action. It is sterile or aseptic and, at the same time, made up of non-vital tissue. Active emboli, on the other hand, are capable of causing harm aside from their mechanical action of blocking blood-vessels. They are either made up of living tissue or pathologic cells, of bacteria or of parasites which have gained access to the circulation. After lodging in the vessels these active emboli produce an infection at the point of lodgment, a metastatic tumor or other lesion.

Sources of Emboli.—By far the great majority of emboli originate from within the vessels themselves, and of these probably the greatest number are derived from thrombi that have been formed in the veins or arteries and have been displaced by one means or another and admitted into the general circulation. Arteriosclerosis is another favorite condition for the development of emboli, not only because thrombi are likely to form in arteriosclerotic vessels, but for the further reason that the pathologic changes consequent upon arteriosclerosis may liberate solid particles which lodge and produce embolism. Endocarditis, especially of the chronic type, is another favorite antecedent of embolism. The emboli coming from the valves particularly, after the same fashion as arteriosclerotic emboli, are formed in that condition. Malignant tumors are notorious for their production of metastases remote from their primary focus, and it may be accepted that most of these remote metastases develop as a consequence of small particles of tumors which have infiltrated the vessels, being liberated from the primary growth and distributed through the circulation. It must not be understood, however, that emboli from malignant tumors invariably produce metastases, for an embolus from this source is capable of producing the same dire results as any other type of embolus. The fat of the patient's body frequently causes embolism, especially in connection with fractures, particularly of the shafts of the long bones, the source of these emboli being chiefly the bone-marrow. Fat emboli are occasionally observed from lesions which do not affect the bone, as in amputations of the breast or other operative procedures. Emboli are frequently derived from suppurative and inflammatory processes and from infected wounds, being due to the dislodgment of thrombi or to the escape of a part of the contents of a suppurative or other pathologic process into the circulation. Rarely bacteria alone are clumped together into such masses as are capable of lodging in the smaller capillaries and producing distinct emboli. Air emboli, while not a common type, are certainly a danger, particularly in operations or wounds that affect the region of the neck or the sinuses of the dura and in cases where hypodermoclysis or other intravenous medication is carelessly done. They have been known to occur as a consequence of failure on the part of an attendant to remove all air from the hypodermic syringe prior to making an injection. Chemical substances insoluble in the blood, which are injected hypodermically or subcutaneously, such as oils and emulsions, of which the most frequently used are the preparations of mercury employed in the treatment of syphilis, if injected into a vein, may cause embolism. Injections of paraffin for cosmetic purposes occasionally give rise to paraffin embolism.

The Pathologic Consequences of Embolism.—Necessarily the immediate result of embolism is an interruption of the circulation through the vessel in which the embolus is lodged. This shuts off the circulation from the region beyond, the behavior of which depends largely on the amount of collateral circulation present or possible, as has already been discussed under Thrombosis. If the circulation is cut off completely from an extremity, gangrene will result. If it is cut off from a certain portion of tissue, as happens in the lungs, brain, liver, kidney, spleen, intestines, an infarct may result, and be either of the red or the white variety, dependent upon the individual case. Degeneration (fatty) of the area whose blood-supply is shut off may occur, and in this instance, as well as in the case of infarction, new tissue formation may take place from surrounding healthy structures and replace the devitalized area by connective tissue, which, when it is formed, appears of a size many times smaller than the original lesion. At the site of lodgment of the embolus the circulation is checked or stopped in the vessels affected, and, of course, thrombosis develops at the site of lodgment of the embolus. So true is this, that after a few days it is frequently impossible, or at least difficult, to say whether the original condition was embolism or thrombosis, owing to the fact that the embolus is imbedded in the thrombus or has entirely disappeared from the point of lodgment. The previous statements are true for all forms of emboli, and they represent the whole truth, so far as bland or aseptic emboli are concerned. If the embolus is active, however, certain changes may develop in addition to the above, dependent upon the nature of the embolus and upon the favorableness of the structure in which it lodges for its further growth and action. Doubtless, many small emboli made up of bacteria or tumor cells lodge in the vessels of the body and are destroyed without producing any discoverable lesion. If they lodge, however, at a point already weakened by a pathologic or traumatic process, they may develop and cause a much more serious condition than the primary one from which they arose. As an illustration of this statement take the development of tuberculous processes, most of which are doubtless of secondary, hematogenous origin, in a bone or other tissue previously reduced in vitality. So, too, emboli from malignant tumors doubtless frequently lodge, lose their vitality, and are absorbed without the production of metastases. This doubtless explains the peculiar distribution of such metastases in certain cases of malignancy. As in cases of septic emboli, so, too, those originating from malignant tumors may produce a condition of much graver symptomatic and prognostic importance to the patient than the primary lesion, often even when the primary lesion itself was not known to exist.

Points of Lodgment.—It may be taken as a broad statement that emboli lodge at some points beyond their entrance into the vessels and are carried to those points by, and in the direction of, the circulating blood. Occasionally they may be carried for a part of their course by the lymph-stream, but even thus they are deposited in the general circulation unless interrupted by a lymph-node or by lodgment in a lymph-vessel producing lymphatic embolism. Rarely, however, retrograde emboli are observed, in which the embolus travels against the current of the blood and lodges at a point in the vein further removed from the heart than the point of origin. By virtue of the structure of the circulatory apparatus one would naturally conclude that emboli originating from the veins would necessarily lodge either in the portal distribution of the liver or in the capillaries of the lung. There are a few exceptions to this rule, and they pass under the name of *paradoxic* or *crossed emboli*, which, though unmistakably forming in the veins, are lodged in the capillaries from the arterial side and are of such size as to render their passage through the pulmonary capillaries impossible. They pass from the right auricle through the foramen ovale into the left auricle, thence into the arterial circulation. The possibility of this occurrence is all the more impressed when one considers that this foramen is imperfectly closed in fully 80 per cent. of cases. Emboli which originate in an artery or which are deposited in an artery lodge either in the branches of the vessel or at a point of bifurcation. Those arising in the veins lodge in the first group of capillaries too small to let them pass, namely, either in the liver or in the pulmonary artery or sometimes in the right heart, if they are very large. Small infected emboli tend to lodge at points where the circulation is slowest or where the resistance of the tissue is most reduced, except, of course, when they reach vessels through which they cannot pass. Owing to gravitation influencing certain emboli there seems to be a tendency for them to enter the lower branches of a vessel rather than the higher ones, according to the position occupied by the patient at the time. The vessels most frequently affected by emboli, in their order, are: pulmonary, renal, splenic, cerebral, iliac; and, while others are affected far less frequently, there is probably no vessel in the body secure against the possibility of embolism. The condition of the artery may serve to determine the particular point at which the embolus lodges.

Symptoms of Embolism.—The symptoms of embolism, like those of thrombosis, are very variable, and they vary for the same reason already mentioned under that heading. If an embolus lodges in a large artery of an extremity pain is almost invariably felt. It is sudden and severe, and frequently is described by the patient as producing the sensation of a blow. In the internal vessels pain may or may not attend upon the lodgment of emboli, and, when the vessel affected is a small and unimportant one, will probably produce either no symptoms whatever, or symptoms of such an obscure nature that diagnosis is impossible. If an embolus lodges in an important internal vessel it may produce sudden death, as it frequently does, or, failing this, severe and permanent crippling of the structures which receive their blood-supply through the blocked vessel. If an embolus lodges in an important structure, but cuts off the blood-supply from only a small portion of it, or if it lodges in the brain, in what are known as the "silent areas," no evidence of such an occurrence is likely to be present. The temperature in cases of embolism may remain normal, or even in the bland variety may be raised somewhat above normal, while in the septic types there will appear such symptoms in a few hours or a few days as one might expect from an extension of an infectious process.

In surgical work there are certain special forms of emboli which concern us particularly. They are: thrombotic emboli, emboli derived from tumors, bacteria from foci of infection, fat and marrow emboli, medicinal emboli, especially oils, mercury, and paraffin. It is necessary to call especial attention to certain features conected with each of these types of embolism, with a view particularly to their prevention.

In all cases of thrombosis where the thrombus is of such an extent as to deserve the name it is necessary to follow out the rules already laid down under the subject of thrombosis, with a view to preventing embolism. It may be wise to repeat that exercise, however slight, on the part of the patient, manipulation, and massage are absolutely contra-indicated, and that the patient should by no means be allowed to arise from his bed until a sufficient time has elapsed to permit fixation of the thrombus *in situ*. Especial effort should be made to prevent infection.

In all cases where malignant tumors are known to be present, and in all tumors suspected of malignancy, it should be the aim of the physician to have the tumor removed at as early a date as possible, so that no emboli may escape from the tumor and lodge at remote points, thus rendering the prognosis hopeless. In conducting their examination physicians often make undue and unnecessary pressure upon malignant tumors, or aspirate them with trochar and canula, or make incisions directly into the tumor for the purpose of procuring specimens for microscopic examination; it should be impressed that any one of these procedures is capable of dislodging fragments of the tumor, which may render hopeless a case which before coming to the physician was capable of cure. Patients themselves have a habit of examining their own tumors, if accessible, and should be instructed to avoid not only such practice, but all possibilities of injury.

The same rules obtain in cases of localized infection, and all traumatism and rough handling of the infected tissues should be looked upon as of no service in the cure of the condition, and at the same time likely to cause the escape of infective masses into the circulation or lymphatics. In fractures, particularly of the long bones, undue manipulation will only increase the amount of fat that escapes into the general circulation (lipemia), and after sufficient evidence is obtained to make a satisfactory diagnosis should by no means be indulged in. In cases of lipemia the fat may escape with the urine, but the quantity of it is less in the urine when it is great in the blood, and vice versa. It rarely shows up in the urine until about twelve hours after the receipt of the fracture, and more commonly not until the expiration of three days.

Air emboli, as has already been said, result from the entrance of air into the venous circulation. The quantity usually received into the vessel must be large in order to produce severe symptoms, but very small quantities have been known to terminate fatally. When a vessel in the neck has been injured, as they occasionally are even by the best of surgeons, owing to the disturbance of the anatomic relationship by the pathology present, air rushes into the open mouth of the vein with a hissing, lapping sound. Various explanations have been advanced as to how air embolism produces death, the most probable one of which is that the air and blood become whipped into a froth in the right heart, and thus interfere with the distribution of the venous blood through the lungs. When such an accident happens the vessel through which the air is entering should be compressed at once, so as to prevent further entrance of air. Sudden death frequently comes as a result of such an accident, but it is by no means universal. It is better in all cases of the kind to locate the vessel, if possible, and cut it between double ligatures or double clamps, so that no air may enter.

In the administration of oily preparations, such as mercury emulsified in an oil, in the treatment of syphilis, or of paraffin for cosmetic purposes, the needle should be filled and inserted home, and a few seconds allowed to pass while the syringe is disconnected from the needle. If the needle, then, is in a vein, blood will be found either to escape from the needle or to force the oil out at the open extremity. In either instance the point of the needle should be shifted so as to avoid the possibility of embolism, which, while it rarely produces death, often results in very distressing and alarming symptoms.

Favorite Sites of Lodgment.—From what has been previously said, emboli may lodge in any of the vessels into which they may be brought by the blood-current; certain vessels are affected apparently with far greater frequency, and when affected produce symptoms not only very apparent, but very alarming.

When an embolus lodges in one of the coronary arteries of the heart sudden death usually occurs. But it is not constant. When the patient survives such an accident, either fatty degeneration of the affected muscular area or infarction takes place. The symptoms of embolism of the coronary arteries, if not fatal, are usually marked and alarming; however, there may be no symptoms. They are cardiac asthma, precordial pain, a feeling of anxiety, dyspnea, a sense of oppression, or angina. The heart action is feeble and likely to be attended with arythmia or tachycardia. Death usually follows such an attack in a day or two, but is not constant. The degenerative changes consequent upon impaired nutrition to the heart produces a gradually increasing weakness of that organ.

Embolism of the large arteries of the extremities cannot be distinguished from thrombosis except by the suddenness of the onset, and this is not an altogether reliable differential symptom, for thrombosis may produce a sudden onset. The history of the case, and the knowledge that certain conditions exist in the body which might lead to one or the other of these conditions, will be extremely helpful in differentiation.

Embolism of the arteries of the kidneys may be latent. On the other hand, it may be attended with sudden and violent symptoms, accompanied by confirmatory changes in the urine. After a major operation, following thrombosis of any type or as a consequence of any condition capable of producing embolism, sudden pain may appear in the dorsolumbar region, and the urine subsequently secreted may show blood and albumin. This could scarcely be interpreted incorrectly, but less typic cases doubtless often escape recognition.

The most common type of the condition is that affecting the pulmonary veins. The symptoms here, too, are not constant, and vary all the way from a transient or unrecognized disturbance to sudden death. In the latter instance the patient, without warning, suddenly cries out, catches at the precordial region on account of agonizing pain, becomes pale, pulseless and unable to breathe, and dies instantly. If death does not occur, the pallor, anguish in the heart region, oppression and dyspnea, attended with few or no physical signs at the outset, should lead to a correct diagnosis. Later the pallor gives way to cyanosis, the patient becomes anxious and restless, and physical signs, dependent, of course, on the volume of lung involved, appear. They are not of constant type, but moist râles, impaired breathing, and resonance are the signs more commonly found, usually in a lower lobe; the patient expectorates abundant frothy sputum which may be blood-stained. The blood-pressure is low and the heart rapid and often irregular. Cough is usually absent, respiration is increased in rate, often rapid, and deep inspiration gives no relief to the intense air hunger.

Embolism of the cerebral vessels is identical in symptomatology with thrombosis, but it is not attended with prodromal warnings. Sudden death may occur, or paralysis of certain groups of muscles is soon produced here, as in other conditions, which impair or destroy the function of brain centers.

Prognosis of Embolism.—Naturally, the prognosis of embolism is as varied as the importance of the various vessels subject to it. Doubtless many emboli lodge without the slightest subjective or objective evidence; but when emboli lodge in the more important vessels the outlook for life and limb is very often grave, even when instant death is escaped. Embolism, from a surgical standpoint, is of the greatest interest, as it is chief of the few conditions capable of wiping out a technical masterpiece in the twinkling of an eye, and stands always a menace, however slight, against an otherwise perfectly safe major operation.

The prognosis of emboli which contain or are made up of septic bacteria is altogether bad; it is the beginning of septicemia or pyemia, and, though the emboli may be too small or lodged in vessels too unimportant to produce symptoms of embolism, the result of such distribution of sepsis is exceedingly grave.

The entrance of air into the vessels in small quantity usually produces no harm; there are, however, exceptions to the rule, and even small quantities of air should be excluded from medicaments which must or may enter the blood-vessels. Large quantities of air are often fatal; this is thought to be due chiefly to the air and blood being whipped into a froth in the right heart.

Treatment.—The treatment of embolism is divisible into preventive and curative.

Preventive Treatment.—Every precaution should be observed to prevent embolism, and this should be especially impressed in certain lesions and in certain surgical procedures. The plan for prevention of embolism in cases of thrombosis has already been given. In cases of fracture all unnecessary manipulation must be avoided, and if it is necessary to move the patient a considerable distance it should be permitted only after satisfactory immobilization. In operations on fat individuals the dissections should be made with knife and scissors, never by tearing and bruising the structures. Doubtless a certain amount of fat enters the vessels in all such cases, but it should be held at a minimum. In operations on the neck and upper thorax continued watchfulness must be exerted for severed veins—they should be, if possible, clamped or ligated before incision. If air is heard to enter such a vein, it should be blocked at once and caught up, preferably during expiration. All hypodermic, intramuscular, and intravascular injections should be guarded against carrying air into the tissues. I have seen air forced into a vein during intravenous saline injection due to the intern mistaking the level of water outside the bottle for the level within. All oily substances, all substances, indeed, which are insoluble in the blood should be injected through a needle large enough to allow the escape of blood during the few seconds the syringe is disconnected from the needle after insertion of the latter, and disconnection should never fail to be made.

Active Treatment.—There is little to do in the ordinary case of embolism except to meet the physiologic requirements as well as possible. Rest in the recumbent position, control of pain with opiates, moderate stimulation of the heart, and administration of oxygen by inhalation, if disturbance of respiration demands it, cover the routine of general treatment. To this it must be added that whatever local demands arise are to be met *pro re nata*.

In cases of air embolism it has recently been suggested that, owing to the interference of the froth in the right heart with the circulation, the indications are best met by injecting 300 c.c. of normal saline solution containing 20 to 30 min. of adrenalin chlorid, 1: 1000, directly into the right heart through the open vein in the ıeck.

Embolism of a large vessel of an extremity should be treated t once by incising the artery, removal of the embolus, and arterial uture.

CHAPTER XXVIII

ANEURYSM

ANEURYSM is a cavity or sac filled with blood and communicating with the lumen of an artery. The limiting wall may consist of one or more arterial coats, of normal tissues, or of new-formed fibrous tissue. Ordinarily aneurysm may be defined as an abnormal permanent dilatation of an artery, but the definition above is made more comprehensive to cover arteriovenous aneurysms and diffuse aneurysms.

Types.—Aneurysms are classed as true or false. A true aneurysm is one whose sac consists of the coats of the artery. The term is widely used to signify that the sac must be made up of all three coats, but such a classification has only caused confusion. A false, or spurious, aneurysm is one whose limiting walls are not made up of vascular coats, but of normal or adventitious structures. The false aneurysms may be circumscribed, where an artificial sac has developed, or diffuse, in which the blood is limited only by the anatomic spaces into which it has escaped. It is little more than arterial hematoma. It is of no practical value to distinguish between an aneurysm whose sac is made up of all the arterial coats and one whose sac is made up of one or two of them; but it is important to distinguish one whose sac is made up of vascular coats from one whose sac is not.

The classification may be given, then, as follows:

- True aneurysms
  - 1. Cylindric.
  - 2. Sacculated or sacciform.
  - 3. Dissecting.
  - 4. Cirsoid, or plexiform, angioma.
  - 5. Arteriovenous
    - Varicose aneurysm.
    - Aneurysm varix.
- False aneurysms
  - Circumscribed.
  - Diffuse.

A cylindric aneurysm is produced by a uniform dilatation of the artery, and assumes a spindle shape usually rather than the cylindric.

Sacculated aneurysm is due to a dilatation of the arterial coats from one side, the remainder of the circumference of the artery remaining more or less undisturbed. The opening from the lumen of the artery into the sac may be small as compared with the size of the sac.

cting aneurysm is due to the escape of blood through the arterial coats and the forcible separation of these m each other. The plane of separation may be between nd media, within the substance of the media, or between ıd adventitia. There may be a single opening or there two, so that the blood may circulate from the vessel one and into it again through the other. According to the ssification into true and false aneurysms this constitutes an liate step (Kaufmann).

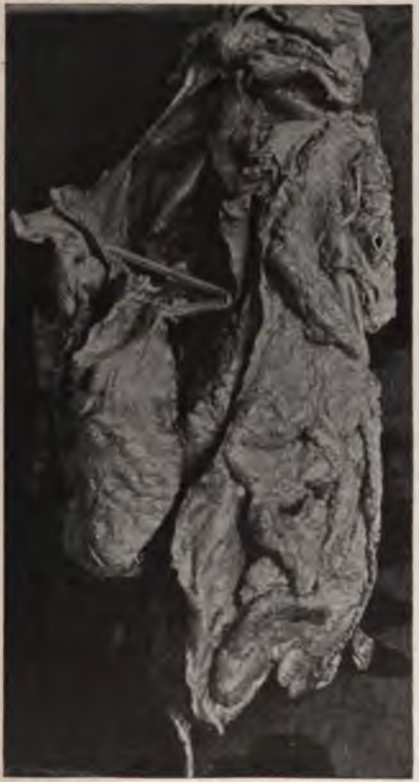


Fig. 82.—Dissecting aneurysm of the aortic arch.

id aneurysm is sometimes classed as an aneurysm and a tumor. As a matter of fact, it belongs to neither; it is a elangiectasis. It will be discussed further under the cap- Vascular Tumors. It is a dilated, elongated, tortuous r group of arteries, and tends to affect certain regions, y the anterior branch of the temporal.

An arteriovenous aneurysm is one produced by the communication of an artery with a vein. There are two types—varicose aneurysm, in which communication is not direct, there being an intervening sac, and aneurysmal varix, in which the communication is direct. In varicose aneurysm the sac and the vein at the point of communication are both dilated, and in aneurysmal varix the vein is dilated at the point of communication. In both the vein pulsates at its dilated portion.

The circumscribed false aneurysm is one in which the blood escaping from the artery is confined to that region by surrounding connective tissue in the form of a bag or sac. The diffuse aneurysm is not limited to any definite form, and the blood may dissect its way among the anatomic structures as far as the blood-pressure and the particular location of the aneurysm may require.

Etiology.—The causation of aneurysm is due to one of two conditions, or to a combination of these two factors, namely, an increase in the blood-pressure or a reduction in the strength and elasticity of the arterial coats. Hence, when the arteries are damaged the usual pressure of the blood may be sufficient to cause aneurysm, and this is all the more likely to happen if from physiologic, pathologic, or therapeutic causes the blood-pressure is increased.

The conditions favoring a high tension of the arteries are excessive eating, especially of nitrogenous food, exercise, especially if violent, such as is engaged in in athletics, running, rowing, boxing, wrestling and foot-ball, and anger or excitement. Pathologic conditions which favor it are general arteriosclerosis, nephritis, uremic and eclamptic conditions, angina pectoris, and convulsions; the latter raise the blood-pressure by virtue of the muscular exercise incurred. The therapeutic agents raising the blood-pressure include all drugs which stimulate the heart and constrict the arteries, chief among them being adrenalin, strychnin, and digitalis or its derivatives.

The changes in the arterial coats which favor loss of elasticity and resistance include, first of all, traumatism, which, by destroying one or more of the arterial coats, and often in addition related anatomic structures which offer additional support, may be the direct and sole cause of aneurysm in individuals whose blood-pressure is normal or below normal. The nature of the trauma is immaterial. It may be produced by blows, cuts, gunshot, or even by so slight an injury as the passage of a needle through the vascular walls. It is the establishment of a traumatic severance of the coats that counts. Second, must be included all those pathologic changes that may result in sclerosis or atheromatous degeneration, and it may be stated here that *a priori* aneurysm would be most common at those points in the arterial system where these changes are most frequent and intense. Since these arterial changes are a concomitant of old age, senility is given as one of the predisposing causes of aneurysm. Syphilis is another cause of atheroma and sclerosis of extremely common occurrence, and is the chief cause of early hardening of the arteries. Chronic interstitial nephritis, gout, diabetes, and obesity are accepted as causative factors, and excessive use of tea, coffee, and tobacco have been held as causes.

Once the walls are crippled the predisposing factor is established, and only a sufficient blood-pressure is needed now, as an exciting cause, to establish aneurysm.

In arteriovenous aneurysm the communication between the two vessels is established as a consequence of trauma—a bullet, nife, or needle penetrating both vessels at once and short-ciruiting the blood-stream through the opening.

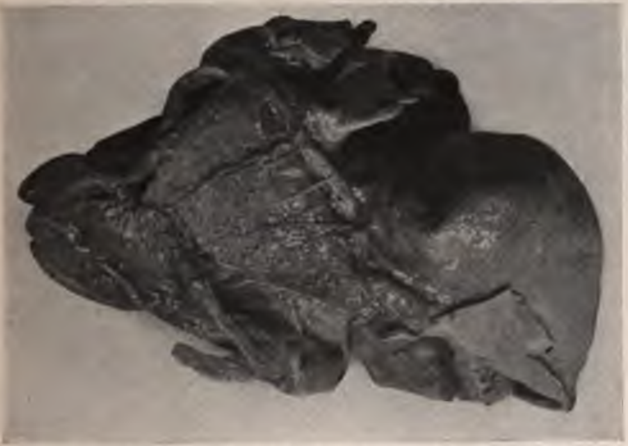


Fig. 83.—Aneurysm of the first division of the aortic arch.

Pathology.—An aneurysm consists of the sac and its contents. The nature of the sac is sufficiently understood from what has een said already. The contents are either fluid blood, clotted lood, or the organized or semi-organized remains of blood-clots. s the blood circulates in the peripheral zone of the sac its rate of otion is slowed, and, often favored by the condition of the lining f the sac, coagulates, forming a clot lying concentric with the sac. This produces a red clot, which as it grows older becomes paler, dheres to the wall, and begins to be converted into cicatricial issue. Meantime a second clot may form on the internal surface of the first, and the size of the aneurysmal sac may be still further increased by continued dilatation of the sac; so the clot forms in layers which are concentric, the outermost being the oldest, the palest, and the most completely organized.

Signs and Symptoms of Aneurysms.—The most prominent sign of an aneurysm, and the sign most universally accepted as diagnostic of the condition, is that it is a pulsating tumor lyin in the course of an artery, usually one of the more importan arteries. The pulsation is synchronous with the heart-beats an

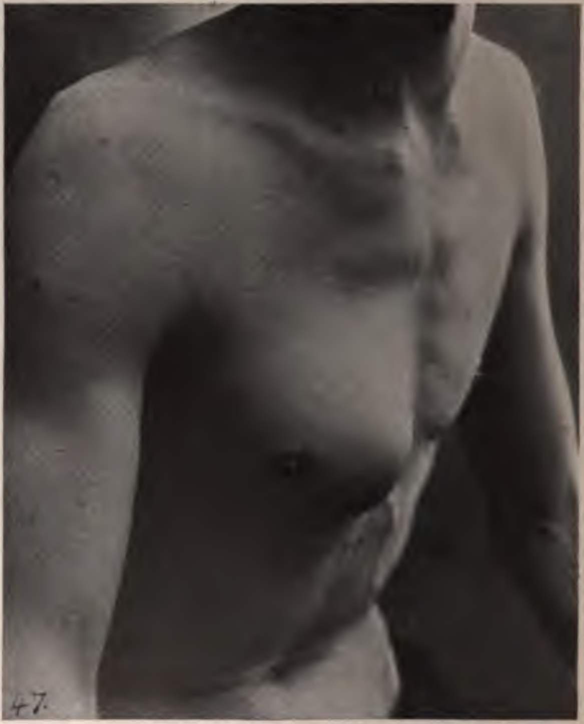


Fig. 84.—Aneurysm of the aortic arch in a syphilitic thirty-one years
Several ribs are completely absorbed.

of the same rate. Pressure on the artery supplying an aneurysm *i. e.*, proximal to it—stops pulsation in it, and it becomes smal as the blood it contains is forced out by the elastic contraction its sac. Pressure on the artery leading from an aneurysm—*i.* distal to it—increases the size and tension of the sac. By stead uniform pressure on the aneurysm itself the size of the tumor m be reduced, but only to the extent of its content of fluid bloo The pulse distal to an aneurysm may be slightly retarded, so th a comparison of the two sides of the body shows the pulse on t diseased side striking a little after that of the other is felt. The pulsation of an aneurysm is centrifugal in direction, the reason for which is readily explained on physical grounds, and entirely unlike the pulsation transmitted to a tumor or an abscess overlying an artery; in the latter instance there is no expansile, centrifugal effect, but only a lifting of the mass away from the artery. Hence, if such a tumor be palpated by the two hands, one on either side of it, they are not separated during pulsation, whereas in aneurysms they are separated.

On palpation the surface of an aneurysm is smooth and even and, it may be, fluctuant, unless the sac be filled with clots. The

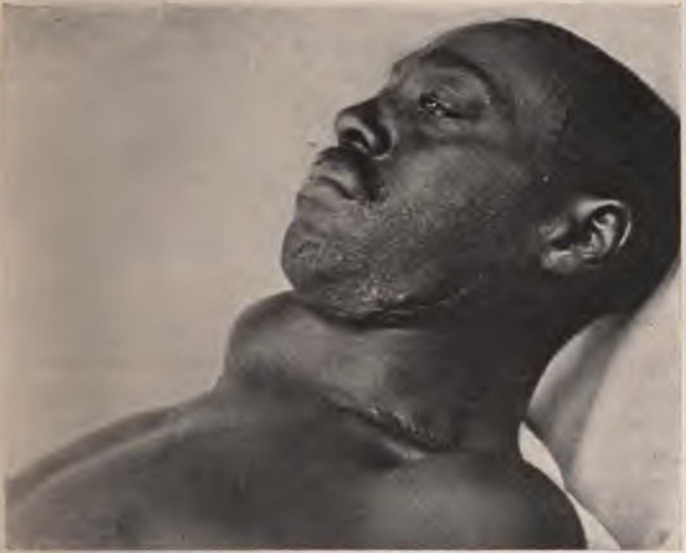


Fig. 85.—Aneurysm of right common carotid.

ze varies, but in the largest vessels it may reach the size of a hild's head. They are rarely larger than an orange.

By listening to an aneurysm one may hear the aneurysmal ruit, a purring sound produced by the passage of blood through he cavity. It is almost constant, and when distinctly heard can e mistaken for no other sound. The only trouble is that it is most ifficult to recognize in precisely those cases where its detection would render the greatest service, namely, in deep aneurysms, as of the thorax or abdomen. The bruit of an aneurysm is more closely imitated by the uterine souffle of pregnancy than by any other normal sound. It is also simulated sometimes when an artery has been partially obstructed, as may occasionally be heard in the neck in cases of empyema. Palpation may reveal a more or less distinct thrill.

Aneurysms may exist indefinitely without the causation of symptoms, or they may produce, by virtue of their location, such obscure symptoms that they are of no value to the clinician and no diagnosis can be determined until postmortem. One of the frequent symptoms of aneurysm is pain. This may occur independently of the location of the mass, but is more severe and more common when the aneurysm is situated in such a position that it may press upon important nerves. Marked interference with the return circulation may develop as a result of pressure of the aneurysm on the veins in relation with it. This may result in edema, thrombosis, and the whole train of lesions following in the wake of severe passive hyperemia.

By its pressure upon surrounding structures destruction or crippling may occur to such degree that the damage done thereby causes more alarm than the aneurysm itself. Thus, an aneurysm of the arch of the aorta may cause paralysis of the recurrent laryngeal nerve and consequent aphonia; or, by pressure on the anterior bony wall of the chest, cause its entire disappearance by absorption, so that the pulsations may be both seen and felt. This absorption advances to such a stage that the aneurysm may rupture externally and in an instant pour out all of the patient's blood. So, too, the vertebræ and other bones may also be absorbed.

The mechanical presence of a large aneurysm is capable of producing symptoms referable to structures whose function is independent of the vascular system, just as a tumor or cyst similarly situated might do. Moreover, the sensory nerves which are pressed upon may produce various paresthesias, as itching, numbness, formication.

Course.—The usual behavior of aneurysms is toward a bad end. They continue, as a rule, to enlarge, until by rupture, pressure, or complication they cause the death of the patient. Spontaneous cure is a rare termination. It may be brought about by thrombosis of the whole cavity of the sac, by the escape of a mass from the lining thrombus, which plugs the main outlet and produces thrombosis and ultimately a cure. When rupture occurs it may take one of four courses: first, into an adjacent vein, causing secondary arteriovenous aneurysm; rupture into the tissues, causing either a diffuse aneurysm or gangrene of the part; rupture into an important serous cavity, with sudden pallor and death; rupture externally and death by hemorrhage. An aneurysm may rarely become infected and suffer disintegration of its sac and the contained clots. Gangrene may result from pressure due to im pingement of the mass on the return veins, by rupture and the escape of large quantities of blood into the tissues, and by thrombosis or embolism which blocks the arterial outlet.

Treatment.—The treatment of aneurysm falls under two headings—non-operative and operative. It is but just to say at the outset that the treatment should, when feasible, be operative, as this offers much better results when it can be done; however, there are many aneurysms so situated as to be so far not amenable to operative treatment and many conditions which contra-indicate surgical interference. Hence, the non-operative treatment must continue to be employed.

NON-OPERATIVE TREATMENT.—It is the purpose of all non-operative plans of treatment to reduce the rate of flow of the blood, to increase its coagulability, or to combine the two. This favors the formation of thrombi in the sac, and produces cure along the lines indicated by observation of spontaneous cures. The results are accomplished by various methods, some of which are antiquated and no longer employed.

Tufnell's plan is based upon the fact that rest reduces the blood-pressure and the number of heart-beats, and that reduction of the quantity of fluid and diet increases the coagulability of the blood. These observations were put into practice by Tufnell almost to the limit of tolerance. His plan allows a minimum of food—3 ounces of meat, 8 ounces of milk, 4 ounces of bread, and a small quantity of butter during each twenty-four hours, with as great restriction of fluids as possible; the patient must rest in bed without rising, and be free from mental anxiety and worry. The plan must be followed for several months to be effective. If necessary, the patient may take a rest from the treatment and return to a moderate diet for a week or two, and then return to the abstemious plan outlined. The most that can be said for the plan is that it has occasionally resulted in cures.

Valsalva recommended venesection, which might be repeated from time to time, rest, and starvation diet. It is practically the same as Tufnell's plan.

These plans have outlined the chief features of the rest cure, but it will rarely be possible in this country to carry the measures to the extreme recommended.

Lancereaux's Plan.—Gelatin injections into the subcutaneous tissues remote from the aneurysm have been used because of the power of gelatin to increase the coagulability of the blood. Doses of 100 c.c. or more of a 5 to 10 per cent. solution (Carnot's solution) in normal salt solution are used, and repeated every ten to fifteen days. It is a dangerous plan of treatment, positively contra-indicated if there is renal disease, and has occasionally produced tetanus. Hence, if one essays its use the most rigid sterilization is enjoined. It is of questionable value.

The pain of aneurysm is often amenable to potassium iodid given in moderate doses (20 to 40 gr.) three times a day. It seems to serve the purpose as well in non-syphilitics as in syphilitic cases.

Cure has been undertaken by forcible manipulation of the sac, with a view to breaking up the clot and allowing it to lodge at the outgoing vessels. For manifest reasons the plan is dangerous and should not be employed.

Pressure by various devices has been employed upon the artery on either side of the aneurysm with occasional success. Manual pressure produced by several individuals working in relays, tourniquets, weights, compresses, and such like represent the variety of devices employed.

Electricity has been employed, and perhaps the most satisfactory plan for its use is by the electrolytic action of needles introduced into the cavity of the sac. It is unsatisfactory.

Injection of astringent and coagulating drugs is no longer employed, but the old plan of introducing a fine wire through a small hollow needle or canula inserted obliquely into the sac has been successful often enough to warrant its continuance, and shows some splendid results. The wire should be very fine, incapable of corrosion, sterile, very long, and wound in such manner before its introduction as to guarantee that it will, when introduced, spread itself throughout the sac. The plan, of course, is not without danger.

Operative Plans.—The operative plans may be subdivided into three groups: First, those which remove or destroy the aneurysm *in toto;* second, those which leave the sac, but by means of ligature shut off the circulation sufficiently to admit of coagulation; third, those which essay to reconstruct the artery. The first plan is the most certain of cure when it can be safely employed; both the first and second groups presuppose an adequate collateral circulation, and a knowledge of anatomy sufficient to warrant that the ligatures will be so placed as to avoid destruction of the vessels which must supply blood to the parts distal to the aneurysm. The third plan is ideal when the location of the aneurysm and the quality of the vascular wall permit its employment.

The oldest method, that devised and employed by *Philagrius*, of Macedonia, gives certain relief from the aneurysm and from the danger of recurrence or complication. It consists in ligation, both proximal and distal to the sac, and complete extirpation of sac and contents.

Antyllus' method was to ligate the artery, both proximal and distal to the sac, incise the sac, and clean out its contents, and has in it the possibility of relief in most cases.

Hunter's method consists in ligation of the artery on the proximal side of the aneurysm and at some distance from it. This is especially a valuable plan where the aneurysm is associated with severe disease of the arteries, as the vessel is in worse condition near the aneurysm. It has been most frequently practised in ligation of the femoral artery at the apex of Scarpa's triangle in cases of popliteal aneurysm.

Anel's method is to ligate the artery proximal to the sac and close to it. A little reflection will show that this plan, while not as good in certain instances as Hunter's plan on account of the pathologic changes in the arterial wall, may be applied in many cases where Hunter's could not be used.

Brasdor's plan is the ligation of the vessel close to the aneurysmal sac on the distal side.

Wardrop's plan consists in the ligation of one or more of the main branches of the artery distal to the sac. For example, the external carotid may be ligated in case of a large aneurysm situated low down in the common carotid.

All these plans are to be employed with careful application of the ligatures at such points that they will not cut off the blood-supply from collaterals which must nourish the structures distal to the ligatures. These, it must be remembered, may be rendered ineffective, either by an unwise location of the ligature, so as to place the collateral vessels all on one side of the point of ligation, or by the use of unnecessarily large or improperly located incisions, or by rough handling of the tissues or their laceration by retractors.

The third plan seeks neither to excise the aneurysm as a whole, nor to interfere with the structures in relation with the sac; it also proposes to conserve the collateral circulation more perfectly than can be done in any other plan. It is known as the plan of Matas, its inventor, or, as he calls it, endo-aneurysmorrhaphy, and it is precisely that the aneurysm is dealt with from its internal rather than its external surface that, in Matas' opinion, gives it its chief value. The difficulty of doing the operation of total excision, manifestly the most satisfactory of the already described plans, or the double ligation (Antylus), and incision and packing of the sac, and the fact that they are more likely to be followed by hemorrhage, infection, or gangrene than are those done according to Matas' plan, have served as stimuli to its adoption.

Matas' plan embraces those methods of procedure to be determined by the type of aneurysm and the conditions encountered on entering and cleaning out the sac. The methods are the obliterative, the restorative, and the reconstructive.

Up to a certain point the procedure is the same in all three methods. The incision is made down to the sac; the vessel is clamped above and below the sac sufficiently only to control the passage of blood through the lumen. The sac is opened from one end to the other and thoroughly cleaned out, and the openings of all branches leading from the sac are sought and closed by suture. If the condition found is such as to preclude the possibility of success with the second or third, or if the aneurysm be distinctly of the fusiform variety, if the vessels are too hard, too degenerated, and inelastic to encourage the establishment of a new artery, the first plan is employed. The sides of the sac are then sutured to each other firmly from one end to the other, and additional sutures are placed in tiers till the whole sac is obliterated. Th second of Matas' procedures is the restorative method, useful i sacculated aneurysms which communicate with the artery throug a slit-like opening through the side of the vessel, and in which th original shape of the vessel is maintained except for the slit. I this instance the edges of the slit are sutured to each other l continuous or interrupted sutures and the blood-stream turned i to test the efficiency of the sutures, which may be reinforced a various points if necessary. The sac is then obliterated by suture, as described above. This reëstablishes the artery, and, unles a thrombus should form, not only removes the aneurysm and its dangers, but, if successful, escapes the greatest danger of th ligature plans, which are attended by gangrene of the extremit i more than 7 per cent. of the cases.

The *reconstruction plan* is employed in cases of fusiform a rysms in which there remains no part of the original arterial in an intact condition. The coats of the sac must be "firm, ela and resistant, and the two openings leading to the main arter on the same level, in close proximity, and situated at the bot of a superficial or readily accessible sac." After clamping the a ries and opening and cleaning the sac a rubber tube is introdu into the lumina. It should be large enough barely to enter vessels. After introducing the tube, the sides of the sac sutured so as to make the reconstructed portion equal in diame to that above and below. When the sutures are introduced th are left untied until the tube is removed. The same steps followed here as in the previous procedures to test the closu which, if unsatisfactory, is reinforced. Then the sac is appro mated over the reconstructed portion by additional tiers of sutur

In cases where obliterative aneurysmorrhaphy is to be pr tised in an extremity it is wise to test the efficiency of the c lateral circulation by removing all blood from the limb Esmarch's plan and placing special clamps on the vessel, wh does not allow the circulating blood to pass. It is applied tightly enough when pulsation ceases in the distal branches. The reappearance of the capillary circulation in and the maintenance of the warmth of the skin indicate an adequate collateral circulation; it has been proved in actual practice that such a return in five hours was sufficient. Failure of such return of the circulation suggests great danger of gangrene in case any obliterative or ligature operation is done.

The possibility of increasing the efficiency of the collateral circulation by repeated prolonged temporary obstruction of the main artery for a considerable period prior to operation increases the efficiency of the collateral circulation.

Subsequent to any operative plan certain important features must be religiously enforced. In the first place, the dressings should be applied loosely, so as to avoid the most insignificant interference with the circulation; second, the part should, if possible, be elevated somewhat to encourage easier return of venous blood, and, third, the temperature of the part must be maintained artificially if the circulation is inadequate.

Arteriovenous aneurysms are in some respects much less amenable to treatment than the usual forms. The ideal plan, when practicable, is separation of the artery and vein and closure of the rent in each by suture; or closure of the vein laterally and resection of the crippled segment of the artery and end-to-end anastomosis. The plans of ligation of the artery or of both artery and vein on either or both sides of the aneurysm are often unsatisfactory, and if both vessels are important, as they usually are, is likely to fail or to produce gangrene in a considerable percentage of the cases.

Expectant treatment by compression over the aneurysm or over the artery proximal to the aneurysm is justifiable in aneurysmal varices, but should not be relied on in varicose aneurysms where circumstances will admit operative measures.

Cirsoid aneurysms are, from the standpoint of treatment, the most formidable, and offer the least hope of cure. When they are of limited extent they are best treated by total excision; if they are very large, the operation may be done at several sittings. Ligation of the main vessel leading to the aneurysm is rarely successful; so also are the plans of injection and pressure. If an extremity is extensively involved amputation will probably be required.

CHAPTER XXIX

VARICOSE VEINS, VARICES, PHLEBECTASIA

Definition.—Varices are veins which have become permanently dilated; they have lost their elasticity and are often tortuous.

Arborescent varicose veins, or varicosities, are frequently observed on the chest, abdomen, back, and thighs, especially of stout individuals; they are sufficiently described by their name, as they resemble branching twigs. They are very small and of no clinical importance.

Etiology.—Usually several factors combine in the causation of varicose veins. Disease of the vessel walls, especially inflammatory processes which weaken the resistance, reduce the elasticity, replace the muscular coats with fibrous tissue, and cause retraction of the valves, is a very favorable factor in their establishment. If, added to these conditions, conditions are present which interfere with the flow of blood through the veins, a backward pressure is established which consummates the development of varices. As the backward pressure is increased the nutrition of the vein walls is diminished and the characteristic pathologic changes are still further favored. The backward pressure of blood is favored by both anatomic and pathologic changes, as well as by physiologic. The normal erect position of man favors the development, for instance, of hemorrhoids, varicocele, and varices of the long saphenous vein with great frequency. The absence of valves in the spermatic veins and the rectangular junction of the left one with the left renal vein especially favors left-sided varicocele. The presence of pelvic tumors and thrombi in the common femoral or iliac veins, as well as cardiac lesions, produce obstruction very favorable to varices in the long saphenous.

Hepatic lesions interfering with the portal circulation favor internal hemorrhoids. Pregnancy, constipation, and the standing position favor the development both of hemorrhoids and of varices in the long saphenous.

Heredity must be mentioned as an etiologic factor, as an inherent weakness of the vessel walls may unquestionably be transmitted by parents to their children.

Pathology.—The veins themselves are usually more tortuous than normal. There may be segments that appear to be normal and others that are thinner or thicker than normal. The thickened portion is due to the formation of fibrous tissue, and the thin bulging spots are produced by excessive dilatation. Occasionally the openings into these dilated segments become closed and blood-cysts form, or two or more of them, by lying in contact, lose their intervening walls and become a single cavity. The tissues surrounding varicose veins atrophy somewhat in consequence of the continued pressure; this is especially true of the skin, which becomes thin along the course of the vessels and often ruptures. The veins are more closely adherent to their environs than normally, and may be densely attached to them. Within the veins the blood-current may be so sluggish that thrombi form. By organization these thrombi may produce permanent obliteration of the veins and result in a more or less complete cure; or they may calcify and remain indefinitely in the form of phleboliths, or vein-stones.

Symptoms.—The symptoms produced by varices are chiefly indirect—*i. e.*, they depend on nutritional disturbances, complications, and mechanical interference with function rather than upon the varices *per se.* Hence, the individual, usually in middle life, twenty to fifty, complains of discomfort, for example, in the lower extremity, especially on standing or walking a great deal the leg becomes tired or numb and aches. These symptoms disappear on rest and elevation. In many cases of varicose veins of either of the three usual types—viz., hemorrhoids, varicocele, or varices of the lower extremity—extensive changes may occur with no discomfort and no crippling of function. On the contrary, moderate developments in either of these regions may cause severe and distressing symptoms. If the deep veins are involved it is impossible to recognize their presence. They are usually associated with varices in the superficial veins. Swelling and edema are frequently associated with varicose veins of the lower extremity.

On examination of the part affected there is usually little difficulty in recognizing the true condition unless complications obscure the field. The superficial veins, large or small, or both, in the leg and thigh, the two saphenous veins and their tributaries appear as dilated, tortuous, nodular cords running beneath the skin, through which the color of the blood shows blue, the color being deeper at the thinnest spots. The cord-like ridges are soft and collapsible on pressure and disappear on uniform compression or elevation of the extremity, only to return on release of the pressure or resumption of the dependent position. The atrophy of the skin and connective tissue is attested by the groove-like feel along the course of the veins. Thrombi may be felt if present in superficial veins, and occasionally phleboliths are recognized.

Complications.—Nutritive disturbances are responsible for most of the complications arising from varicose veins. In varicocele the most distressing feature, aside from the possibility of pain, is atrophy of the testicle, as shown by the diminished size and increased softness. In the lower extremity the chief complications are ulceration, hemorrhage, intractable eczema, thrombophlebitis, and a brawny, indurated edema, which may so thicken the tissues and enlarge the leg as to obscure the causative varices and give the appearance almost of a moderate elephantiasis. Ulceration is quite common, and usually appears in the lower half of the leg. The ulcers may be minute and superficial or enormously large and deep. They are chronic, and may be either callous or erethistic. When healed they tend to recur. The skin of these legs is often pigmented brown, more especially if ulceration is present. Hemorrhage occurs on the surface or in the tissues. It occurs on the surface as a result of traumatism or severe muscular effort; the latter cause is also responsible for the deep hemorrhages. Eczema is often responsible for the chief discomfort; nothing offers permanent relief for it so long as the veins remain untreated. Thrombophlebitis may result in cure, in phleboliths, or in inflammation and suppuration. Its recurrence at frequent intervals is extremely annoying and ulcers are apt to follow it. The great thickening of the tissues, resembling elephantiasis, is usually associated with ulceration, which in its turn is the most frequent complication.

Prognosis.—After their thorough establishment varicose veins remain permanently, tending only to grow worse or to develop their annoying or dangerous complications. In some instances they appear during pregnancy, remain until parturition, and do not reappear until the next pregnancy. Such cases are brought to fully developed varices by repeated gestations. Varicose veins do not endanger life *per se*, but they impair the usefulness and activity of the individual, and, aside from the discomfort produced by their interference with the circulation, may, by development of complications, result in the complete incapacity of their host.

Treatment.—The treatment of varicose veins may be looked upon as preventive, palliative, and curative. The treatment of the various complications is nothing different from that of similar lesions arising from other sources, except that they cannot be satisfactorily managed until the varices have been first looked to.

Preventive treatment is, of course, largely a removal of causes. Many cases could be avoided entirely by avoiding improper practices or removing mechanical structures which are known to result at times in this condition. Usually the veins are pretty well advanced in varicosis before the surgeon is consulted, and his advice is only valuable in prevention of further advancement. Such advice, then, must be directed against all mechanical obstruction, however slight, against maintenance of the standing posture for long periods, as in bookkeeping, and toward encouragement of elevation of the part if possible. Walking is better for such patients than standing, and sitting is better than habitual walking. The function of the heart must be maintained, the bowels must not be constipated. If the varices result from portal obstruction, their further development cannot be prevented, except where it is possible to remove the obstruction surgically or by therapeutic means, or to establish adequate collaterals to relieve the portal vein of a part of its blood, as is done by omentopexy.

Palliative treatment consists in the performance of all that has been said on the subject of preventive treatment. Preventive treatment is intended to accomplish at an early stage exactly what palliative treatment does later. Further, palliative treatment must give artificially the support to the veins that they have lost in their change from the normal to the varicosed condition. This is accomplished by the use of elastic bandages or, better, elastic hose made of silk and rubber, and, in case of varicocele, well-fitted suspensories. The use of massage adds something to the comfort of the individual, but nothing permanent. Injuries are to be avoided, and the earliest appearance of complications must be a signal for prompt attention.

Curative or radical treatment is always surgical. It consists in obliteration or removal of the veins affected. The plans of obliteration consist in the application of ligatures at single or numerous points in the course of the veins, with or without excision of the vessels between ligatures. It is preferable probably to double-ligate and sever the veins. The most frequently employed of such plans are Trendelenburg's ligation at the saphenous opening and Schede's circumcision (circular incision to the deep fascia and ligature of all bleeding points), and the application of ligatures at various points along the diseased vessels. Sometimes obliteration is practised, ill-advisedly, by injection of escharotics into hemorrhoids. Multiple ligature may be practised by the open or subcutaneous method; the former is preferable. No curative treatment can be offered where both superficial and deep veins are varicosed.

Removal of the veins is the most satisfactory plan of treatment. It is illustrated by the various methods of excising hemorrhoids, almost universally practised, by Bennett's operation for varicocele by double ligation and excision of the intervening segment and approximation of the stumps, and by the ordinary excision of varices in superficial veins through incisions coextensive with the length of vein excised, or by Mayo's plan of making short incisions at long intervals, removing the intervening portion of vein with an enucleator.

Radical cure of varicose veins must not be undertaken when the deep veins have previously been obliterated.

CHAPTER XXX

LYMPHANGIECTASES AND LYMPH-EDEMA

THE causes of this condition, which result in interference with the lymph-circulation sufficiently to cause filling and dilatation of the lymph-channels and spaces, are either obstruction or obliteration of the lymph-vessels. Pressure by tumors and pathologic accumulations, as ascites, and by scar-tissue may collapse the vessels; they may be blocked by the direct growth of cancerous tissue into the channels or by the presence of Filaria sanguinis-hominis (see Elephantiasis), or by occlusion or obliteration of the channels by thrombi which develop as a sequel to repeated inflammations, as in recurrent attacks of erysipelas.

In case of obstruction of the lymph-current the vessels dilate and become more or less tortuous, and may be seen or felt beneath the skin, appearing much as varicose veins, but not reaching so great a size, and, of course, without the bluish color of the latter. The skin becomes swollen and, to all appearance, edematous, pitting on pressure, and presenting a peculiar whitish appearance not observed in other conditions. The swelling shades off gradually into the surrounding normal tissue. Occasionally dilated vessels appear the size of a large shot, and smaller vesicles may cover the whole affected areas. The swollen surface pits on pressure, just as in ordinary edema. When the thoracic duct is obstructed the walls may rupture and cause an effusion of chyle into the pleural (chylothorax) or the peritoneal cavity (chylous ascites). Injuries of the skin, however slight, are to be avoided in cases of lymphangiectasis, as the channels and spaces are easily penetrated and a large discharge of lymph will continue to escape, often in spite of our best efforts to control them. The loss of lymph does not impress the patient unfavorably, but its continued presence on the skin surface will macerate and irritate the skin.

Lymphangiectatic tissues are very easily infected and are susceptible to repeated inflammation.

The prognosis of lymphangiectasis is unfavorable when the vessels are completely obliterated; in those cases where the obliteration is not so extensive the remaining vessels may be able to assume the requisite additional function similar to the collateral circulation in obstruction of blood-vessels. There is little danger to life or limb except such as the complications or the cause may entail.

Treatment.—The course to pursue is indicated by the cause and by the extent of the lesion. If the cause of obstruction can be removed the lymphangiectatic edema will disappear; if there are larger lymphangiectases, they should be dissected away. If there is reason to believe that the case is not one of complete and permanent obstruction, relief may follow uniform pressure and elevation. When fistulæ appear they are to be dealt with by cauterization and pressure or by incision and packing, unless the case can be radically relieved by excision.

In cases of lymph-edema and lymphangiectases of large extent the plan of establishing new routes for the lymph flow by transplanting the fascia has been undertaken, but it has not been pursued far enough to make satisfactory observations.

CHAPTER XXXI

ELEPHANTIASIS, ACQUIRED PACHYDERMIA

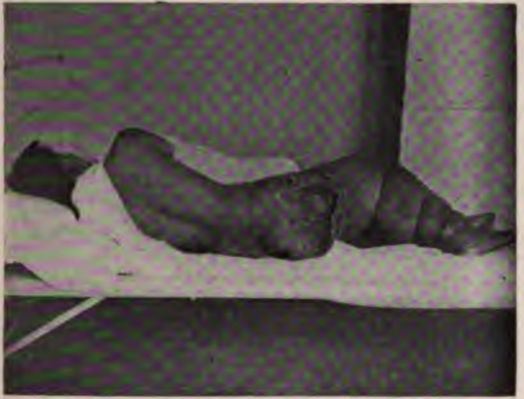
Definition.—This condition is a hyperplasia of the skin and subcutaneous tissues; the cuticle, too, is often hyperplastic. Even the intramuscular connective tissues may be affected, due to interference with the circulation of lymph.

Etiology.—The causes of elephantiasis are not uniformly the same. The majority of the cases are undoubtedly produced by the parasite Filaria sanguinis-hominis (elephantiasis filariosa), indigenous in the tropics, where by far the greater number of cases occur. This parasite in its adult state is capable of blocking the lymph-channels sufficiently to obstruct the lymph flow and cause elephantiasis, which occurs by no means in all infected cases, some tropical countries showing the filaria probably in 12 per cent. of the population, the majority of whom are and remain in good health. Elephantiasis arabum is, therefore, to be recognized as a complication that may arise in these cases. The larval stage of filaria is passed in the blood, and they can be easily demonstrated microscopically in blood drawn during the habitual resting hours, hence usually at night.

A second cause of elephantiasis (E. nostras) is repeated inflammatory processes in the skin, such as erysipelas and eczema. The lesion may be congenital and grow gradually worse, especially if frequent inflammation occurs, as it is prone to do. A condition resembling elephantiasis very closely (E. phlebectatica) is often associated with varicose veins of the leg. Similar lesions are also often associated with chronic ulceration. The latter two causes, however, do not usually produce the enormous changes seen in elephantiasis.

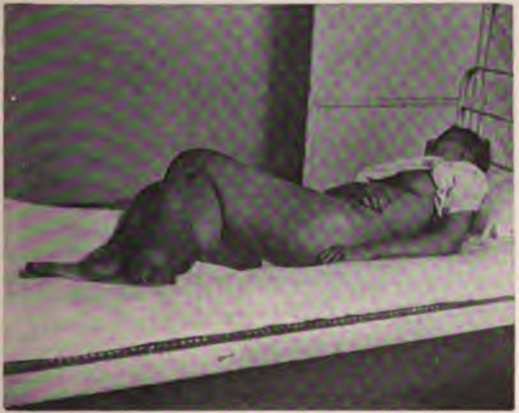
Finally, there is a condition known as elephantiasis neuromatosa, associated sometimes with von Recklinghausen's disease, and usually affecting one lower extremity. It differs from elephantiasis in the absence of edema and the presence of the enlarged nodulated nerves.

Pathology.—The changes produced in elephantiasis are due to a hyperplasia of the connective tissue. The skin and subcutaneous tissue are chiefly affected; the epidermis may also be hyperplastic. However, in the more severe cases the intramuscular septa may be affected and the fat and muscular tissue may be ed by the gradual development of connective tissue. tis sometimes forms a part of the pathologic picture and es may be irregularly thickened. Occasionally osteomata



–Case of elephantiasis from which streptococcus and Bacillus prodigiosus were recovered (McCabe).

in the connective tissue of the skin. The hyperplasia ither a dense, firm mass of tissue or a less dense, softer struc- "edematous, gelatinous tissue."



87.—Another view of same case shown in Fig. 86 (McCabe).

gnosis.—The regions commonly affected are the lower ities, the penis and scrotum, the labia and the clitoris. casionally observed in other parts. The parts become unly enlarged, often many times their original size, so that

the leg may measure three or four times its normal circu
the scrotum or the labia may reach far below the knees
clitoris may reach the size of a well-developed penis, a
pearance and shape look wholly unlike the normal
The surface may be hard and board-like or soft and e
The skin surface may be nodular, or covered with papil
tirely smooth; it is sometimes scaly, as in ichthyosis. The

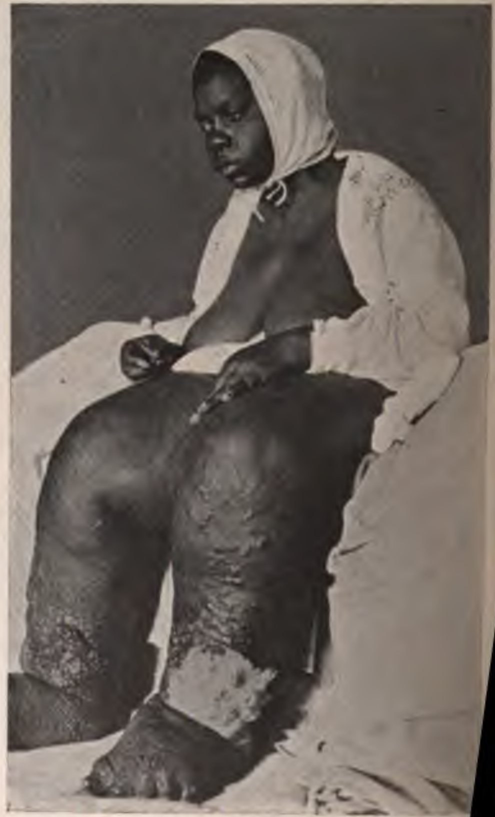


Fig. 88.—Elephantiasis in a negro woman.

be either translucent or pigmented. The creases a
skin are much deeper than normal and the oppose
are moist, macerated, and foul smelling.

From a subjective standpoint little or no disc
felt except the incumbrance of the gradually incr
an unweildly part. On the other hand, the discomf
to intense suffering, both from the burden of the

CHAPTER XXXII

ANESTHESIA

ANESTHESIA may be conveniently classified as local and general. In local anesthesia it is the intention to suspend sensibility (especially that for pain) in the part to be operated on, or in a region which embraces the field of operation. General anesthesia produces not only entire loss of sensibility, but of consciousness as well.

Local Anesthesia.—Local anesthesia is produced in two ways, namely, by the applications of cold, and by the employment of drugs which so act upon the nerve-endings or their fibers that no stimuli are received or transmitted by them.

The employment of cold for the production of anesthesia is of very limited usefulness, being restricted to superficial lesions. When the depth of an incision must be much greater than the thickness of the skin this method is unsatisfactory; it is likewise available only when the necessary work requires only a few seconds for its performance.

Anesthesia is produced by any compound or mixture that will freeze the surface. The drug employed usually is ethyl chlorid, which should be sprayed on the surface until the latter is covered with a coat of white frost, when the work must proceed at once. Carbon dioxid is colder, more easily handled, and in the cities much cheaper than ethyl chlorid, and can be applied and confined to the desired area much more easily; it is molded into the proper shape and held in contact with the tissues for ten to thirty seconds. Quicker and more satisfactory anesthesia is produced if the lump of snow can be pressed firmly enough against the part to obstruct capillary circulation. Cold should not be employed as an anesthetic in individuals whose tissue resistance is poor, especially in diabetics.

The drugs possessed of anesthetic properties are numerous. The more common ones are carbolic acid, magnesium sulphate, cocain, eucain, stovain, and novocain. Of these the most frequently employed is cocain, of which the full dose is 1 gr. Eucain is used in the same way, and the dose is the same as cocain. It is said to be less toxic. Novocain is similar in action to the others, but the maximum dose may be as high as 8 gr. when employed in extradural anesthesia.

'he methods of employing these drugs are by absorption, ndermic injection, by infiltration (Schleich), by hypodermic tion, by injection into nerves (nerve blockage), by intra- us injection, by intradural injection (intraspinal analgesia), by epidural injection.

taw surfaces, granulating wounds, and especially mucous ibranes can be satisfactorily anesthetized superficially by ing rather strong cocain solutions (5 to 10 per cent.) in contact them for a period of from five to fifteen minutes. The tonsils adenoids are thus especially susceptible because of their t absorptive power. Bleeding wounds cannot be anesthetized by this plan, and it is employed in general more as a prepara- for instrumentation than for operation, except on mucous aces.

The *endermic plan* for local anesthesia is to inject anesthetic tions into the skin sufficiently to raise a white bleb along the se of the proposed incision. Anesthesia is instantaneous, and nds more on the physical action of the fluid mass on the nerve- s and endings than on the anesthetic contained, as is attested he dilute solutions of cocain required ($\frac{1}{10}$ to $\frac{1}{8}$ of 1 per cent.), y the similar action of fluids which possess no anesthetic proper- This plan is carried still further in hypodermic anesthesia, as first impressed by Schleich (see Schleich's solution). Anesthe- s produced in the subcutaneous structures in the same way as ne skin by the injection of large quantities of weak solutions cain or eucain, and this plan is much more satisfactory in more nsive operations than the injection of limited quantities of nger solutions, because, by using the larger volumes of fluid, only are all the tissues reached, but the combined mechanical thetic values of the fluid are attained. Thus, one may easily erniotomy, goiter, and hemorrhoid operations by local anes- ia, provided no rough handling of the tissues be engaged in, inexcusable practice even when the patient is profoundly er general anesthesia.

Nerve-blocking is employed in producing local anesthesia, as this plan the injection of 2 or 3 minims of a 1 or 2 per cent. tion of cocain into the nerve-sheath will completely anes- ize its whole distribution. Of course, when a region is supplied more than one sensory nerve all must be treated in the same nner. Nerve-blocking demands only small doses of cocain, reas by the hypodermic or the infiltration method toxic doses ld be requisite to produce even much poorer results. The es are reached through incisions, the anesthesia for which produced by infiltration. By these combined methods such or operations as resection of the upper and lower jaws can be satisfactorily done; while it is ideal for such minor operations as the amputation of fingers and toes, in which an attempt is made to inject the solution in the region of the nerves, but not to locate and inject them individually. Amputations of the hand or foot may be similarly executed. This plan of blocking is frequently rendered necessary by the presence of inflammation in the part to be operated, rendering direct anesthesia of the part inadvisable.

Intravenous local anesthesia has recently been extensively employed by German surgeons. After rendering the part bloodless by the Esmarch plan a tourniquet is applied above and another below the operative field, and a solution of cocain injected into a vein between the two. This follows the various distribution of the vessels of the part and anesthetizes the entire volume embraced between the tourniquets, so that operations of any degree may be done.

Intraspinal analgesia is in necessary cases a very useful plan, but it must be looked upon only as an unsafe and unsatisfactory alternative when other plans cannot be employed. Here the cocain (or stovain) solutions, ½ to 2 per cent., are injected in 5-minim doses through the third and fourth lumbar interspace into the subarachnoid space of the cord. No injection should be made until the needle has been placed so that cerebrospinal fluid escapes. The method is not as safe as general anesthesia, and should be used only when the latter is positively contra-indicated. Anesthesia is not always complete, and the sequelæ are often more disagreeable than those of general anesthesia. The blood-pressure is reduced; nausea, vomiting, headache, and fever follow. Intraspinal analgesia is a special plan of nerve-blocking, and here as elsewhere anesthesia is produced only in the part distal to the site of injection.

Sacral anesthesia is the latest adventure in nerve-blocking. It is extradural injection of anesthetic solutions into the sacral canal, and safely anesthetizes a very definite group of structures. Cocain cannot be given in sufficient dosage; novocain is employed instead. The formula recommended by Siebert is as follows:

Sod. bicarb., C. P. Merk	0.2	gm.
Sod. chlorat	0.2	gm.
Novocain	0.75	gm.
Aq. dest.	50	c.c.

Twenty to 25 c.c. of this solution, after momentary boiling and the addition of 5 minims of adrenalin chlorid, 1 : 1000, is injected into the sacral canal through the membrane which marks its lower limit, the hiatus sacralis; the patient remains in the sitting posture from eight to twenty-five minutes, or until anesthesia is complete, and then assumes the position required for the operation. It is employed in all cases where the operative field is supplied by the distribution of the sacral plexus, namely, in "prolapsus ani, hemorrhoids, perineorrhaphy, and other procedures in the perineal and genital regions; furthermore, in obstetric operations."

Similarly, *epidural anesthesia* is being employed for anesthetizing the dorsal and lumbar nerves.

The advantages of local anesthesia are manifest. The preoperative preparations for general anesthesia are avoided, and postoperative discomfort is spared the patient. The danger is less, the time of operation in minor cases shorter, and the expense is not so high. But especially those major cases where general anesthesia is contra-indicated, on account of the general condition of the patient, on account of the nature of the operation or the pathology for which it is offered, local anesthesia has a much wider and more useful field than it has received at the hands of the profession.

Local anesthesia may be prolonged somewhat, usually by combining adrenalin chlorid with it, unless the latter is contra-indicated or feared, owing to the possibility of secondary hemorrhage.

General Anesthesia.—General or pulmonary anesthesia is produced by the inhalation of the vapors of various drugs which are liquid or gaseous in their natural state, such as ether, chloroform, nitrous oxid, ethyl chlorid, and ethyl bromid; by combinations of these, for example, alcohol-ether-chloroform mixture (A. C. E.), and by using two or more of them in succession.

Prior to administration of a general anesthetic, in all except the most insistent emergency cases, a thorough physical examination of the patient should be made.

Physical Examination.—This should be such as to determine as accurately as possible the condition of the heart, lungs, kidneys, and throat especially; and of less frequent, but not less great importance, the general condition, as one often sees cases in which there is no question about the need for surgery, but a very grave one relative to the patient's ability to tolerate anesthesia. If it is possible to determine the condition known as status lymphaticus it should be accepted as a bar to all forms of general anesthesia, except in the most urgent cases. The history of the patient occasionally reveals the fact that a previous anesthetic has almost proved fatal. In all cases where general anesthesia is contra-indicated, it should, if possible, be supplanted by local anesthesia. In general, ether is, from a theoretic standpoint, contra-indicated in cases of pulmonary lesions, tuberculosis and severe bronchitis, and in cases of nephritis. Many surgeons, however, use it in all their work, as, with improved methods of administration, produces apparently less harm than any other anesthetic, an avoids the objectionable feature of irritation manifested by th old plan of administration. Chloroform is contra-indicated, es cially in all cases who have heart lesions or disease of the he muscle, and is absolutely to be tabooed in status lymphati and in patients who have recently had diseases which frequen affect the heart, such as diphtheria.

Preparation should be begun a sufficient time prior to the h for anesthesia. In the first place, every patient's mouth sho be put into a sanitary condition by a competent dentist a few d before operation. This precaution is a great step toward prevention of postanesthetic pneumonia, and should be insis upon. The sanitary condition should then be maintained by use of a tooth-brush and a sanitary lotion or powder, all of wh to this day are strangers to many patients. The upper air-p sages should be cleansed if there is a chronic excess of secreti and the operation should be postponed, if possible, if there is acute inflammation of the respiratory tract. The stomach shou be and remain empty for several hours prior to the operation; food should be allowed within ten or twelve hours; long periods starvation are ill advised except in gastro-intestinal work. Wat may be taken in moderate quantities up to the time of operatio If the stomach contains food at the time of operation it should emptied by lavage. The bowels should be emptied by a modera purge two days prior to operation and by enema the evening ar the morning before operation. Severe purgation should not b allowed, and purgation within twenty-four hours preceedin operation is not so satisfactory as an earlier one, aside from bein objectionable on technical grounds in surgery of the alimentar tract. For several hours prior to operation the patient shoul be kept quiet in bed.

The choice of an anesthetic is, aside from what has been sai above, determined largely by the duration and nature of th operation, often by the caprice of the surgeon. In cases of shor operation, where rigidity and tremor cannot interfere with th work, or where an expert can administer it, nitrous oxid may b used; ethyl chlorid has the same advantages and disadvantage of quick anesthesia, early recovery, rigidity, and tremor. Chlor form is preferred by many in similar cases, and possesses the ad vantages without the disadvantages of the other two; with prolonged anesthesia may be produced if necessary; and, whil this has been done with nitrous oxid administered with oxyge or by ethyl chlorid, the practice has comparatively few adherent So far as practice in general work is concerned, ether, chlorofor and nitrous oxid are the standard anesthetics, and in the United States ether is employed singly or in conjunction with nitrous oxid by the great majority of surgeons.

The Relative Danger of Anesthetics.—Aside from special dangers arising from anesthesia in patients who have certain pathologic conditions, there is an element of danger, small but not to be forgotten, in the administration of anesthetics in general. A drug that is powerful enough to cause loss of consciousness and sensibility can, when pushed far enough, or in the presence of certain often obscure conditions in the body, and with the aid of certain stimuli or traumatisms, produce death. Hence, not only should the danger of anesthesia be recognized by the surgeon, but the patient should be apprised of this danger in general, and also of any special danger in his own case. The mortality from anesthetics is small, but it is just as likely to occur in those who are anesthetized for slight as for severe operations. The safest anesthetic is nitrous oxid, with a mortality of one in 250,000 or 300,000; ether comes second with a death-rate of 1 in 18,000 to 25,000; chloroform kills 1 in 3000 to 5000. The death-rate from ethyl chlorid is not worked out sufficiently to be dependable, but is probably between ether and chloroform, and that of A. C. E. is not established.

The causes of death from anesthesia are: (1) Paralysis of the heart during incomplete anesthesia, especially if chlorofom is being used; this is apt to occur from disturbance of the patient by beginning to operate too soon, especially in the region of the fifth nerve. (2) From asphyxiation, as occurs when the air-passages are obstructed by foreign bodies, enlarged tonsils and adenoids, or by the tongue, and when the lungs are filled with mucus, as in bronchorrhea, or when vomitus or blood is sucked into the trachea. (3) By paralysis of the heart or respiration from overdosage of the anesthetic. The highest centers are anesthetized first, then the centers of motion and sensation, the vital centers last. (4) By the combined shock produced by anesthesia and operation. It must be borne constantly in mind that shock occurs independently of hemorrhage, and that it may be produced during full anesthesia as certainly as in its absence; the surgeon should, therefore, deal as gently with the tissues as possible, whether the anesthetic be local or general. If the danger of shock is anticipated in such operations as the larger amputations, it may be reduced to a minimum by blocking the larger nerves with cocain before severing them. Crushing, bruising, tearing the tissues, especially the nerves, adds to the shock produced. In all cases likely to be attended with shock constant watch should be held on the blood-pressure.

Surgical Anesthesia.—The room should be quiet and free from an audience, but there should always be at least one attendant besides the anesthetist. The anesthetic should be given in small quantity at the beginning by an assistant who is able to gain and to hold the confidence of the patient. If this can be done, and if the anesthetic is not pushed too rapidly, the anesthetist will in some way cause the patient's attention to be directed away from the anesthetic by causing him to interlock his fingers, to count or listen to occasionally repeated assurances made by the anesthetist. In a word, if a bit of suggestion is combined with the anesthetic the course will be much easier, and the formerly described second stage, or stage of excitement, will be eliminated or much less marked. In cases where the patients are very nervous or excitable, as in exophthalmic goiter, Crile has very wisely suggested that the patient be ignorant of the time and the fact of anesthesia by daily allowing him to inhale different drugs through the cone, so that he will consider the real anesthetic as a matter of daily routine and be anesthetized without knowing it. Such cases are especially benefited by a dose of morphin or morphin-hyoscin-scopolamin a half-hour or an hour before beginning the anesthetic.

As the anesthetic is given the patient should be carefully observed by the anesthetist for any untoward change in his condition, who should give notice at once if it is serious. Administering the anesthetic should occupy one assistant's entire attention, and he should not be tempted from his post by a desire to see the details of the operation.

When surgical anesthesia is attained it may be recognized by the disappearance of the reflexes. The eyes look straight away during surgical anesthesia, and they do not move, as in the incomplete stage, by rolling aimlessly and slowly or by a nystagmic movement. Sensation is lost; this is determined by touching the conjunctiva (which is not a wise practice) or by pressing over a sensory nerve, as the supra-orbital. The experienced anesthetist can usually recognize surgical anesthesia by the relaxation and the more or less characteristic respiration, which is even and moderately full. In the administration of ether there is frequently a moderate snoring; it should not amount to marked stertor. In chloroform anesthesia the respiration is usually very quiet.

Once surgical anesthesia is attained, it should be the anesthetist's purpose to hold the patient as superficially under it as possible, remembering always that there are certain parts of an operation which require deeper anesthesia than others. The skin and external mucous membrane are most sensitive and others are often completely insensible, for example, the brain and the peritoneum. The anus is extremely sensitive, especially to divulsion, and the anesthetist should be notified when such a procedure is about to be undertaken, particularly if chloroform is being given, lest the resultant deep inspiration cause an overdose.

Emergencies.—The most frequent source of anesthetic accidents arises from imperfect exclusion of undesirable cases, or if they are recognized as undesirable, from improper preparation. Patients who have myocarditis or fatty hearts, very marked atheroma, advanced nephritis, Addison's disease, or status lymphaticus, and those who have had serious trouble from anesthesia are bad risks, and should be anesthetized, however briefly, only under the direst necessity. Those who are extremely septic are likewise bad subjects. On the contrary, tuberculous patients are, as a rule, easily and safely anesthetized, except in advanced pulmonary cases. In spite of all precautions there will remain a small mortality attached to the administration of anesthetics. The cases due to mechnical obstruction of the air-passages by blood, mucus, tongue, tonsils, and foreign bodies can be easily eliminated at the time or prepared for in advance. The two causes to which attention is especially called are paralysis of the heart and of the muscles of respiration.

In case the heart fails to perform its function, the anesthetic is withdrawn instantly, the patient is placed in an exaggerated Trendelenburg position (except in the presence of large masses in the abdomen which by pressure may further cripple the heart's action); stimulants are to be administered, of which adrenalin chlorid is the most important, and it should be given directly into a vein in normal salt solution. The heart may be stimulated into action by slapping the chest directly over the cardiac region, by massage through the diaphragm in abdominal cases, or directly, after doing thoracotomy. Experimentally the latter has proved to be a wonderful plan; in human practice it has not so far been resorted to extensively.

If respiration fails, one must determine instantly whether or not it is due to obstruction; if it is, the effort is continued by the patient, but it is unavailing, and the obstruction should be removed or relieved by tracheotomy or intubation.

Otherwise the pulse is to be examined immediately, and will probably be found of sufficient volume. The head is lowered and artificial respiration is done with the normal rhythm, not rapidly and excitedly. Oxygen may be used, especially if a Meltzer-Auer or Elsberg's apparatus is at hand, as this plan alone will aërate the blood for an indefinite time. The sphincter ani externus should be dilated or a lump of ice inserted into the rectum and cold applications made to the face. So long as the heart continues to beat these efforts should be continued, but they often prove futile in cases both of cardiac and respiratory paralysis. The faradic battery has been used in these cases of paralysis with questionable results. It is superfluous to add that the anesthetic should be discontinued.

There are certain danger signals which should impress the anesthetist at once, namely, rapidity of the pulse, especially if it occurs suddenly; sudden fall of the blood-pressure in the absence of marked hemorrhage, and dilatation of the pupils, the wider the worse, in complete anesthesia; and they demand that the anesthetic be discontinued, or practically so, until the condition can be righted.

Following anesthesia there is usually a period of more or less prolonged nausea and vomiting. This depends on the anesthetic, the mode of its administration, the quantity consumed, and the duration. Ether more uniformly produces nausea and vomiting than the other anesthetics, but occasionally they may follow chloroform and continue for several days. Ordinarily the nausea disappears by the end of six to twelve hours. This is one of the greatest objections to general anesthesia; and, although it can be reduced to a minimum, so far it cannot be uniformly eliminated. The best plan for prevention is proper preparation beforehand, proper administration by a skilled anesthetist, avoidance of unnecessary delay in the operation, and lavage of the stomach as soon as practicable after the anesthetic. If these fail, various drugs are employed to control the nausea if it is distressing, of which the most important are morphin hypodermically, the objections to which need no mention. Chloretone has been administered with some success. The administration of 1-minim doses of tincture of iodin in 1 dram of water every hour or two seems to give some relief.

CHAPTER XXXIII

TUMORS

Definition.—A tumor is an autonomous growth consisting of perverted cells, maintaining itself independently and at the sacrifice of normal tissues, and functionating incorrectly.

Until the etiology and pathology of tumors are more fully understood no correct definition perhaps can be given. The term "tumor" formerly embraced many lesions (granulomata) which have been removed from this category by advances in our knowledge, which in every instance has limited the scope of the word tumor. What further restriction may be established by future investigations cannot even be surmised. The definition is intended to distinguish tumors as a group from physically similar masses produced by known causes, such as tuberculous masses, gummata, actinomycosis, inflammatory masses, and new tissue formation in general, the causation of all of which we know very definitely, and which are derived from the pre-existing cells in consequence of the action of definite causes. While clinically and microscopically the differentiation between such enlargements is often difficult, yet their behavior upon withdrawal or destruction of their cause is entirely different from that of tumors. The former disappear or are replaced by fibrous tissue, and have not in their cells the power to propagate themselves indefinitely after their extracellular stimulus is gone. But tumors are made of cells a part of whose nature is this perverted tendency to multiply indefinitely and independently of any so far recognized extraneous stimulus; in them it is inherent, intracellular, and the new-cell progeny have the same tendency transmitted to them, which does not occur in inflammatory masses. There is no tendency in tumors toward retrogression and toward cessation of their unnatural course. The cells of inflammatory masses represent an effort of nature to antagonize the cause, or the result which such antagonism produces on them. The cells of tumors represent only the aimless multiplication of cells whose only well-performed function is this very multiplication and self-nutrition in spite of the fate of related tissues of the body as a whole. The same difference is observed in hypertrophies and hyperplasias; producing abnormal enlargement of parts and organs, the cells maintain their proper relation to the general economy. In tumors their behavior is independent of local or general needs and of the tissues from which they are derived.

Benign and Malignant Tumors.—The most important subdivision of tumors is that based on their clinical course, namely, into *benign* and *malignant;* and while there are all degrees between the two, it is of the utmost practical importance, both from the standpoint of prognosis and of treatment, to know in which of these subdivisions a given tumor falls; not that one would wait for the development of the tumor until its clinical course is manifest, but with a view of recognizing microscopically the nature of the growth in its early stages and of advising its host accordingly.

A benign tumor is one that in and of itself has no tendency to destroy the life of the individual. Its presence in the tissues does not *per se* reduce the health and result in emaciation and death. Death may result from a benign tumor, but when it does, it comes in consequence of the physical presence of the tumor, where the tumor behaves precisely as a foreign body in its position would, or in consequence of accident or complication. So by obstructing large vessels, the alimentary tract, the air-passages, or by pressure on the brain or cord a benign tumor may cause death directly; on the other hand, it may become gangrenous or inflamed and suppurate, or bleed in consequence of pathologic change or accident, and produce death indirectly, as would happen if a similar condition were produced in normal tissues.

A malignant tumor is one which in and of itself does produce death invariably if allowed to pursue its course unmolested. It may accidentally kill the patient by its mechanical presence or by accident or complication, and it is much more subject to such than benign tumors are; however, if this fails, death invariably results from the presence of a malignant tumor in the tissues; malignant tumors kill regardless of the ultimate size attained, the small as certainly as the large.

It is necessary for the student of tumor pathology to learn not only the difference in a general clinical way between benign and malignant tumors, but the essential microscopic difference which is the earliest positive plan of differentiation, and the only certain very early differential means at our command.

Rate of Growth.—The rule is that benign tumors grow slowly, while malignant tumors grow rapidly. But the terms "slow" and "rapid" are so indefinite that their significance can be learned only from practical experience. There are frequent exceptions to the rule, for a malignant tumor may exist for ten or more years and the part in which it develops be smaller than normal, while a benign tumor may reach a very suspicious size within a year.

Blood Supply.—Benign tumors, except vascular tumors, are more poorly supplied with blood-vessels than malignant, but this is of more value from the operative standpoint than from the diagnostic, and is of very great importance in connection with the great tendency of certain malignant tumors to be complicated with hemorrhage, which is often uncontrollable and may hastily produce death.

Encapsulation.—The capsule of a tumor is a white connective-tissue sheath surrounding it. The capsule is derived from the accumulation of connective tissue on the surface of a tumor as it enlarges and from the proliferation produced by the growth. Benign tumors are usually encapsulated—*i. e.*, the whole tumor, all of the tumor cells, constitutes the mass within the capsule. Manifestly those benign tumors, such as warts, which do not develop in the midst of connective tissue, are not encapsulated. The capsule may vary in thickness, in one instance being definite and well developed, in another extremely attenuated. Malignant tumors are usually not encapsulated; however, sarcomata, especially early in their course, may be definitely encapsulated, and thus present some of the usual signs of benign tumors; their capsule is not a true, but a pseudocapsule; the difference between the two being that a true capsule contains all the tumor elements within it, whereas a pseudocapsule may contain tumor cells in the substance of its wall, and they may be found also entirely outside the capsule, that is, a pseudocapsule does not contain all the tumor elements within it.

Pain.—Pain is absent from benign tumors except when they involve nerve tissue in their growth, press upon nerve-endings or fibers, or are painful on account of accidents or complications. Malignant tumors are usually painless until they have advanced well in their course, and the physician must never await the appearance of pain as a diagnostic point or draw conclusions from its absence.

Infiltration.—Infiltration may be defined as the growth of the tumor into surrounding structures. Benign tumors do not infiltrate the cells remaining in contact with the tumor and forming a part of the tumor mass, which is definitely delimited. On the contrary, malignant tumors infiltrate surrounding tissues, so that, although the tumor may seem to be definite in its outlines and even encapsulated, one cannot know to what extent cells from the tumor have grown from this mass into the surrounding tissues, or when processes have projected themselves into the lymph-spaces and along various other channels. Thus it is possible to understand how the lumen of a vein may be filled with a process which has extended through the wall by infiltration and grown along the canal; or how a small process may grow out through a foramen and produce a second nodule directly connected with the original mass, as potatoes are with the vine. Infiltration of malignant tumors causes disintegration and destruction of the tissues affected, bone even being no exception to the rule. In many instances infiltration may be recognized by the indefinite outlines of the tumors or by their fixation. The direct growth of cancer cells from one organ into another in contact with it deserves mention here.

Mobility.—Because of their encapsulation benign tumors are movable, which means that they are capable of being moved relative to the tissues which immediately surround them, and not simply that the organ in which they originate can be moved in its relations. When a benign tumor arises from a structure, such as bone, relative to which it cannot be moved, the relative mobility of the surrounding soft parts may be recognized and amount to the same clinical significance as if the tumor were movable in its bed. Benign tumors, especially in the pelvis and abdomen, may become fixed and immovable on account of adhesions to the parietes and viscera; this, of course, is accidental, and offers no solution to the nature of the tumor. It is wise if possible to elicit a history which would determine the presence or absence of such inflammation. Malignant tumors may be immovable from their inception; they may be movable for a time and become fixed later by infiltration, or they may appear as a retrograde change occurring in old benign tumors, and this fixation is one of the important signs of such change. Immobility of a malignant tumor may be recognizable only partially, *i. e.*, not in every direction, as, for example, is shown in the early appearance of Halstead's sign of mammary carcinoma. Immobility may, in advanced stages of infiltration, be so extensive as to fix the organ in which the tumor appears, or several organs may be fixed immovably together and the whole mass densely attached to surrounding structures. So the rectum, vagina, uterus, and bladder may all be involved in one cancerous mass and the whole attached to the pelvic walls. A very important means of determining mobility of tumors of the skin or mucous membrane and of tumors which underlie these membranes is to attempt to elicit the normal gliding of these membranes over subtegumentary structures; if this is absent, it is interpreted as immobility.

Lymph-node Enlargement.—Benign tumors do not affect the lymph-nodes into which the region drains. Malignant tumors of the cancerous type do produce enlargement, which is due to the presence and multiplication of cancer cells within the nodes. Sarcomata occasionally produce lymph-node involvement, but only in special cases. It may become necessary to distinguish between enlargement of lymph-nodes due to cancer cells and that arising from infection of an ulcerative tumor from which no cells have reached the lymph-nodes. This can be surmised only in a clinical way, the cancerous nodes coming up slowly, while those due to infection may enlarge in a very few days. The only certain test is the microscope, and in case of doubt the patient's welfare demands that such nodes be treated as cancerous. Manifestly, inflammation of benign tumors may cause lymph-node involvement.

Metastasis.—By metastasis is meant the escape of a cell or a group of cells from a tumor into the blood- or lymph-vessels, and its lodgment and development in some more or less remote part of the body. The secondary tumors thus formed are called metastases, and produce the same cell types found in the original or primary tumor. Benign tumors do not metastasize; a few exceptions have been observed apparently in cases of adenoma and chondroma, but if benign tumors ever produce metastases it is so rare an occurrence as to have little practical bearing. Malignant tumors do habitually produce metastases. Tumor cells escape into the blood-vessels or lymph-channels and are carried, in the

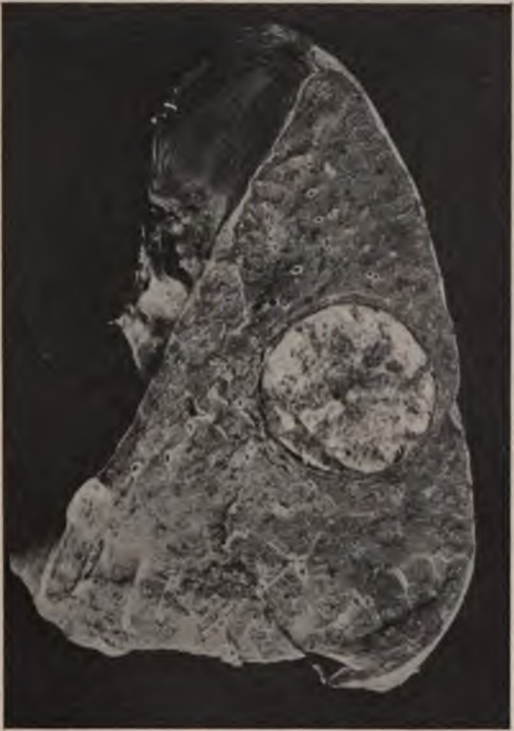


Fig. 89.—Metastasis in lung. Teratoma testis. (× about ½ natural size.)

first instance, to the first vessel too small to admit their passage, and, in the second, to the first lymph-node, and there begin the development of secondary tumors. It must not be concluded that all secondary tumors are metastatic, as will be shown later.

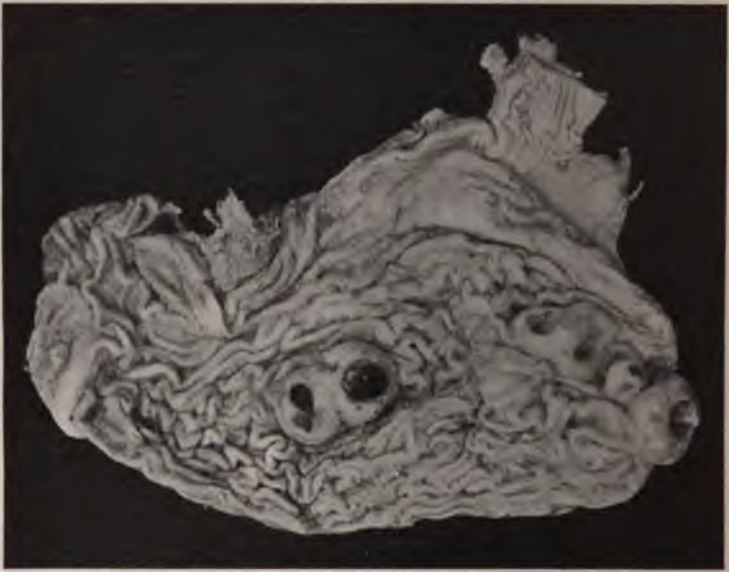


Fig. 90.—Metastasis in stomach. Teratoma testis. (× about ½ natural size.)

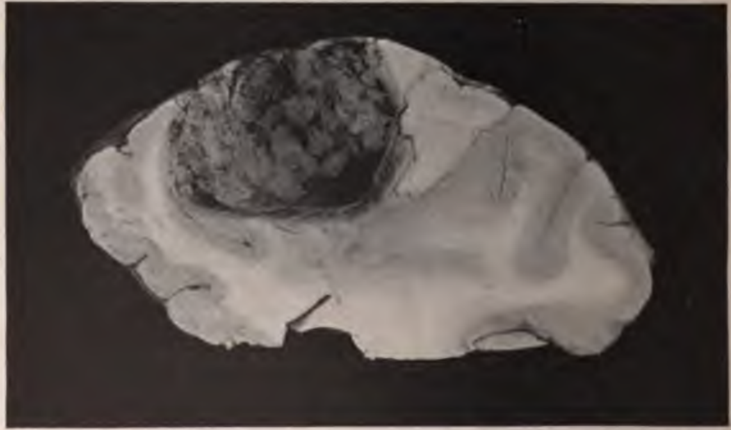


Fig. 91.—Metastasis in brain. Teratoma testis. (× about ½ natural size.)

Ulceration.—As any normal structure may be affected by ulceration, so may any tumor, the benign with less frequency than normal tissue; malignant tumors, especially cancers, with far greater frequency. This is so true that few malignant tumors, indeed, situated in the skin or mucous membrane, or which reach these teguments by infiltration, escape ulceration at some time in their course—some early, some late.

The ulcers are of the chronic, incurable type; no granulations of a healthy nature are seen, and the surfaces of the ulcers are covered with necrotic material, discharge more or less abundantly, and emit the unmistakable odor of decomposing flesh. This odor may, in ulcerative carcinomata, be quite as intolerable as that observed in the worst forms of gangrene. It should be remembered in cases either of carcinoma or sarcoma that incision into the tumor is more likely to be followed by ulceration than by healing; the closer the tumor is to the surface, the greater this probability.

Hemorrhage.—In consequence of two pathologic facts—namely, that malignant tumors invade and weaken the walls of blood-vessels and that they ulcerate—it is easy to understand that hemorrhage is not only liable to occur in cases of malignancy, but that, having occurred, it is more likely to persist or to recur because of the unhealthy condition of the vascular walls and their consequent imperfect physiologic activity. So frequent is ulceration and hemorrhage in cases of concealed cancers of the digestive tract that the latter is one of the most important, though unfortunately too late, signs of this condition relied on by the profession. In addition to the hemorrhage attendant upon ulceration, sarcomata frequently bleed into their own tissues, a very characteristic feature, but present no grave dangers so long as the blood cannot escape. When hemorrhage from an ulcerative surface occurs, it may recur in slight attacks until emaciation and anemia are extreme, or it may be profuse and result in immediate death. Benign tumors do not ulcerate and consequently do not bleed, as a rule; neither are they subject to hemorrhage into the tumor substance.

Cachexia.—It has been shown already that benign tumors do not tend to kill; likewise they do not affect the general health of their host. On the contrary, malignant tumors do invariably affect the general health independently of their local complications, although they may advance to enormous dimensions occasionally without producing great constitutional impression, provided they escape ulceration, hemorrhage, and infection, which add to the intensity of cachexia and to the rapidity of the development. Cachexia is manifested by pallor or, rather, a sallow skin, emaciation, and anemia, and is attended by weakness and anorexia.

Recurrence.—When a benign tumor is dissected out one may be certain in most instances that it is removed *in toto;* consequently it will not recur. But, owing to infiltration, metastases, and the root-like protrusion of tumor tissues into the lymph-channels and similar spaces, one can never be absolutely certain of removing all of a malignant growth, and it is necessary to admit that in a large percentage of cases even the most extensive removal fails to eradicate the whole of the new growth. The cells left *in situ* continue to multiply, and after a time, often amounting to several years, the tumor recurs.

Degeneration.—The cells of the benign tumors are of a type much closer to normal tissue than those of malignant tumors, grow much less rapidly, and are much less subject to degenerative changes than the latter. This fact explains how it happens that malignant tumors are so much more prone to ulceration and disintegration.

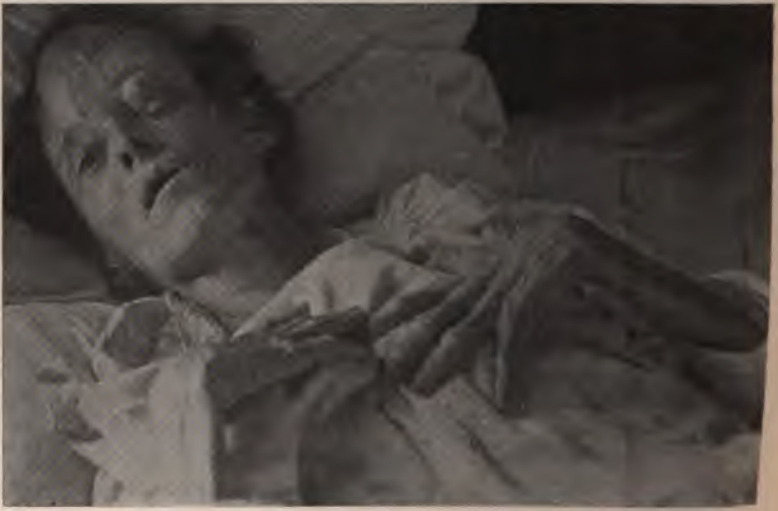


Fig. 92.—Cachexia. Osteosarcoma of cranium. This patient died within three days after this photograph was made.

Microscopic Differences.—The above differentiation between benign and malignant tumors is, as has been stated, clinical. But it is necessary to know the character of a tumor long before these various manifestations occur, and the microscope is resorted to to ascertain the facts. Yet the question arises here, namely, Just what is the essential microscopic evidence which constitutes the proof that a tumor is malignant? It must be stated here that, since it is impossible practically for the pathologist to examine carefully every part of a specimen submitted, he may be unfortunate enough to find no evidence of malignancy in the section examined, while another, near or remote, would show unmistakable proof of it. For this reason the pathologist should, if possible, have the whole tumor submitted for a choice of sections, or the section submitted should be taken from the most suspicious (clinically) portion, namely, the most rapidly growing portion. There can be no question that every specimen of the least uncertainty should be submitted to microscopic examination. In normal tissues cells of certain function are found only in certain relations to the tissues about them. Hence, the epithelium in various parts of the body is found to lie on a connective-tissue substratum. In benign tumors, although there may be much disturbance of structure in a gross or microscopic way, yet this one relation remains undisturbed, and the epithelial cells of the tumor are found always on the right side of the connective-tissue support and in proper relation to it. But in malignant tumors the so-called "insane cells" show evidence of penetration of their supporting tissue in all stages, from the slightest dip below the proper level to invasion of the membrane and into the tissues beyond. The power a cell has to invade tissues contrary to its normal histologic and functional relationship establishes its malignancy. Malignancy cannot be safely diagnosed as suspicious by the pathologist. If the tumor is malignant, it should show the proof. If it is only suspicious as yet, it has surely not reached the stage where the same operation should be done as in cases of certain malignancy. Welch's experience with uncertain cases has led him to the conclusion that they are almost invariably benign. The nearer the cells are in their resemblance to the embryonic type, the greater the probability of malignancy.

The Origin of Tumors.—There are two antagonistic theories as to the source of tumors. The cellular theory is accepted by its supporters as an explanation of the entire list, while those who advocate the parisitic theory explain only certain tumors by it, leaving the remainder untouched (see Etiology of Cancer).

The cellular theory, usually accredited to Cohnheim, proposes an explanation of the origin of tumors as follows: It is supposed that a larger number of cells is produced in the early subdivisions of the ovum both before and after its formation of epiblast, mesoblast, and hypoblast than is necessary for the future development of the embryo into a normal child, and that these cells cease to multiply and remain quiescent alongside of the other multiplying cells and are enveloped by them. Those cells which cease to develop further are known as "cell rests." As the tissues reach a further stage of development toward the normal fetus, when the cells have specialized for the formation of various histologic tissues, still other more highly developed, more specialized cells are converted into "cell rests." From these cell rests tumors are supposed to originate, due to the rest cells taking on, from some unknown cause, a second growth, so to speak, in which their power to multiply is re-established, and that without restriction and out of all relation to local or general demands of the body, and without the power to advance beyond the stage they had reached when they became rests. To this Nicholas Senn added the further item that not only cell rests may produce tumors, but they may originate from imperfectly developed (young) cells which are formed in the course of the healing or regenerative process. Hence, there are tumors of the early embryonic cell type, which are known as malignant tumors, and various tumors of more or less fully developed cells, which conform histologically to the normal varieties of tissue found in the body, and their tissues resemble the normal so closely that one would often be at a loss to differentiate the one from the other. Furthermore, the classification of tumors can be made by considering the embryonic layers of tissue, and subdividing those tumors falling under the respective types in accordance with the histologic structure of the tissue found. Homologous tumors are those forming in tissues of their own type; heterologous tumors form in tissue histologically different.

In this connection it is necessary to impress that tumors which originate from the cells of one of the three embryonic layers never are converted into those which originate from cells derived from another layer. Hence, mesoblastic tumors are characterized by some variety of mesoblastic cells; if benign, they may become malignant, but if they do it is certain that a mesoblastic malignant tumor will result; the same is true of epiblastic and hypoblastic tumors.

Classification of Tumors.—

I. Mesoblastic (Connective-tissue) Tumors:

A. Benign.		B. Malignant.
1. Chondroma,	Lower forms.	1. Sarcoma.
2. Osteoma,		2. Endothelioma.
3. Lipoma,		
4. Myxoma,		
5. Fibroma,		
6. Myoma,	Higher forms.	
7. Angeioma,		
8. Lymphangeioma,		
9. Neuroma,		

II. Epiblastic and Hypoblastic Tumors:

A. Benign.	B. Malignant.
1. Papilloma (Tegumentary Cells).	1. Epithelioma (Tegumentary Cells).
2. Adenoma (Secreting Cells).	2. Carcinoma (Functionating Cells).

III. Mixed Tumors:

A. Teratoma.

CHAPTER XXXIV

CHONDROMA

Definition.—The essential element of this tumor is cartilage.

Classification.—Chondromata are subdivided into ecchondromata, or ecchondroses, enchondromata, and chondromata of soft tissues. Ecchondromata originate from normal cartilage and appear as outgrowths from it, as small and usually unimportant masses; they may be ecchondroma simplex, which remains permanently in the cartilaginous state, or ecchondroma ossificans, which shows a greater or smaller degree of ossification.

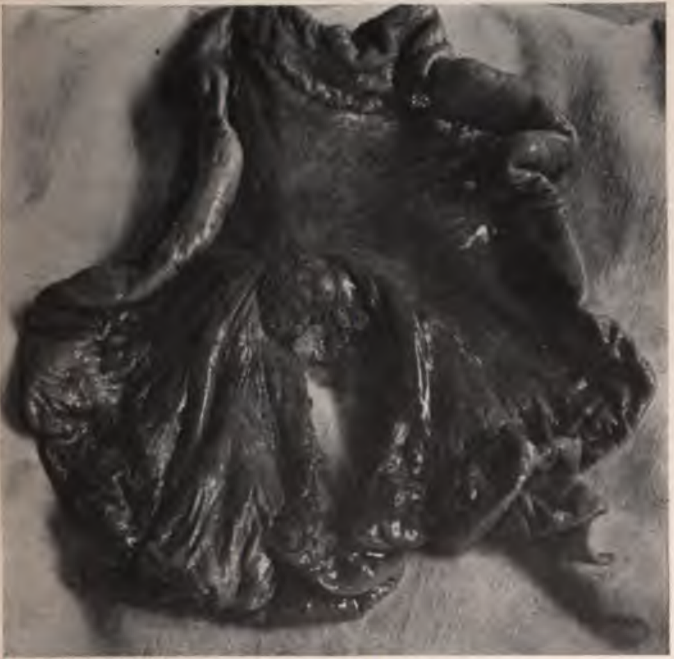


Fig. 93.—Small mesenteric chondroma.

Enchondromata are derived from cartilaginous rests in the substance of normal bone, but always in bone derived originally from cartilage; they do not appear in bones which formed in membranes, such as the cranial bones. They may be peripheral, forming at the surface of the bone, or central, forming within the substance of the bone.

Chondroma fracturæ is a cartilaginous outgrowth from the site of a recent fracture into the surrounding soft parts.

Chondromata appear also in the soft parts, and are consequently heterologous tumors, all of the above being homologous.

Etiology.—Most chondromata originate without discoverable cause, presumably from cartilaginous rests at their point of origin. It is interesting to note that heterologous chondromata are found almost invariably in structures that lie in close anatomic relation to bone or cartilage, or that lie during the fetal state in such relation—*e. g.*, the testicle—and Cohnheim and his followers explain in this way the source of cartilage cells in the soft structures. Traumatism may serve as a cause, as was indicated above by the term "chondroma fracturæ," especially if the injury is received during the period of growth; cartilage rests are also produced in rickets.

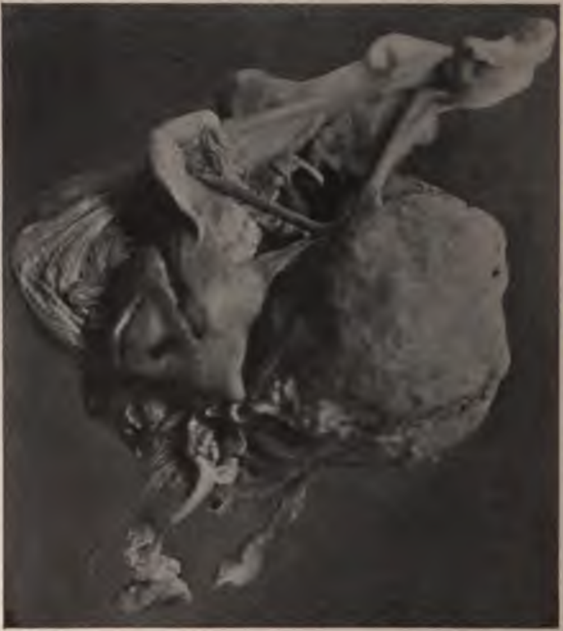


Fig. 94.—Mesenteric chondroma the size of a large orange.

Structure.—The matrix of chondromata is usually hyaline cartilage, although fibrous or elastic cartilage is sometimes seen. The cells are of irregular shape and have no definite arrangement. The blood-supply of the tumor comes through the surrounding perichondral membrane and the connective-tissue septa lying between the nodules. The tumor is usually surrounded by a definite perichondral capsule, but this is by no means constant; it is oftener wanting in the soft tumors. Chondromata are usually of irregularly nodulated form, and the nodules do not contain blood-vessels or connective tissue.

Sites of Formation.—Ecchondromata form in connection with normal cartilage, especially in the larynx, the ribs of old people, and at the clivus Blumanbachii.

Enchondromata appear in connection with the diaphyses of the smaller long bones, particularly the metacarpals, metatarsals, and the phalanges. They are also found less frequently in the larger long bones, especially the femur, and in the irregular bones, of which the most important are the ossa innominata and the scapulæ.

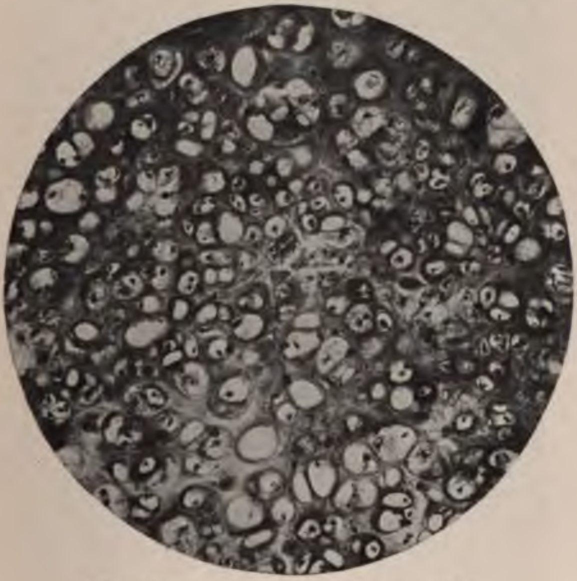


Fig. 95.—Chondroma. (× about 100.)

The heterologous tumors are observed chiefly in the mammary gland, the testicle, the ovaries, the parotid glands, the lungs, and the neck (branchiogenic chondroma). They are also seen in the fascia (See Fig. 96.)

Diagnosis.—Chondromata vary in size from very minute masses to enormous growths larger than a man's head, grow slowly, and are surrounded by structures which are movable in relation to them, except when situated centrally in bone. They are nodular and hard, as a rule, although elasticity may be elicited in them after reaching a moderate size, which distinguishes them from bone. The surface of large chondromata, especially in old tumors, often show soft spots, due to degeneration. Their preference for the osseous system, their development at the ends of the small long bones, their frequent appearance on the hands and feet simultaneously and in great numbers, so that several fingers and toes may be affected, and the deformity resulting therefrom, together with the loss of function, renders their diagnosis easy. The diagnosis may be further cleared up by puncturing the tumor with a sharp needle, which can be forced into the substance of the tumor, except in the central enchondromata, and cannot be forced into osseous tumors. A skiagraph will also show a difference between the shadow of cartilage and bone tumors. In the softer varieties it may be difficult or impossible to differentiate

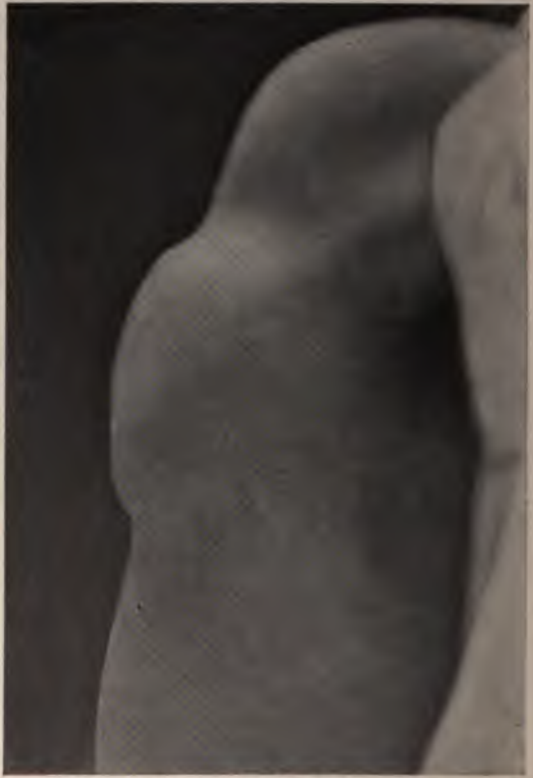
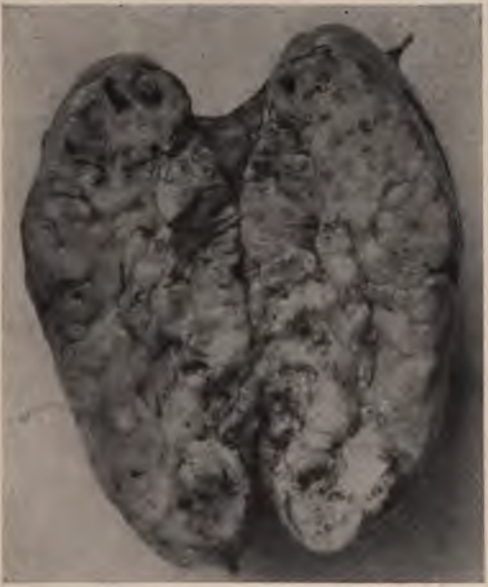


Fig. 96.—Heterologous chondroma over right scapula.

chondroma from sarcoma, especially if regional or remote metastases have occurred, and differentiation is of least necessity here, as the soft ones are especially liable to become malignant.

Variations.—Chondromata sometimes appear as mixed tumors, the more common being osteochondroma, fibrochondroma, myxochondroma, angiochondroma, and chondrosarcoma.

Pathologic Changes.—Chondromata are especially liable to certain regressive changes, namely, myxomatous degeneration and cyst formation; they also become calcified or ossified; in the latter instance they can be distinguished from osteoma by the presence of a thin layer of cartilage covering the surface of the



g.- 97.—Heterologous chondroma over right scapula after removal and section.

umor. Central chondromata occasionally are covered by a bony ell. They may become sarcomatous after existing a long time s benign tumors, and occasionally produce metastases and inltrate surrounding tissues as sarcoma does, without conforming o the latter type in other respects. Rupture of the cysts, ulceraion, infection, and putrefactive decomposition may occur.

Prognosis.—The outlook in cases of chondroma is good. They produce more or less deformity, and, when situated in the region of an articulation, are likely to limit or destroy its function. Of multiple chondromata, those which grow most rapidly should be considered the most unfavorable. If they assume accelerated growth after a time it is an indication of malignancy.

Treatment.—Chondromata should be removed, if removal is possible without mutilation, unless they are so situated as to render the operation hazardous. Slowly growing tumors may usually be left *in situ* without great danger, but they should be observed occasionally by a competent physician, and the patient should be warned of the possibility of malignant change. Always, if possible, they should be removed by enucleation, sparing the surrounding bone and periosteum. When the bone has been rendered useless, when there are positive signs of malignancy, and when recurrence takes place after conservative procedures, resection or amputation should be practised.

CHAPTER XXXV

OSTEOMA

Definition.—An osteoma is a benign tumor whose essential ucture is made up of bone tissue.

Classification.—Exostoses are bony outgrowths from bone. ey are called exostoses when they arise in the medullary spaces spongy bone.

Osteomata are, in accordance with their structure, classified o osteoma durum or eburnum (ivory or eburnated), osteoma ngiosum (spongy or cancellated), and osteoma medullare edullary).

Osteoma fracturæ is an osseous tumor arising at the site of a cture.

Etiology.—Beyond the influence of trauma and prolonged tation nothing is known of their origin. They are frequently editary. They are derived either from cartilage or from iosteum. In the former case they form a subperiosteal tumor novably attached to the underlying bone.

Structure.—The structure of eburnated exostoses is exceed- ly dense and ivory-like, so hard that they can frequently not cut with the best chisels; there are no marrow spaces, or but ignificant ones, no vessels, nothing but solid bone. In the ngy variety the bone-tissue and marrow spaces are both sent, as in cancellous bone, from which it cannot be distin- shed on section. In the medullary type the bony substance still further diminished and the soft tissue is much in excess.

Sites of Formation.—The majority of osteomata form either direct connection with the skeleton or in close proximity to it. terologous osteomata are infrequent. The long bones at the el of the epiphyses and at the insertion of large muscles are orite sites. The bones and sinuses of the face and cranium are nmon sites. Osteoma durum is especially frequent on the flat nes of the skull. *Subungual osteoma* develops as a round, painful dule under the great toe-nail. Osteomata develop from the ver jaw, upper jaw, and the ethmoid, occasionally protruding o the orbit or even from it. Osteoma fracturæ (callus luxurians) velops at the site of fractures and, unlike excessive callus, does t disappear later. Heterologous osteomata are found in the muscles and tendons, in the brain and in the meninges, in the lungs, trachea, choroid, and sclera.

Diagnosis.—The presence of a slow-growing, bony-hard tumor in connection with the skeleton suggests osteoma. It is painless and the tissues are movable over it. The surface may be smooth or nodulated, and the tumor may be pedunculated or sessile. They rarely attain the size of a fist. They do not soften, as chondromata sometimes do, cast a denser shadow in the skiagraph, and cannot be punctured with a needle. Occasionally a periosteal osteoma is movable relative to the bone. Inflammatory enlargements give a history of inflammation and pain and are tender upon pressure. Myositis ossificans can be distinguished by the history of trauma or inflammation, its development in muscles, usually the deltoid, adductor magnus, and quadriceps, and the presence of intact periosteum covering the underlying bone as shown by skiagrams. The general or progressive form of myositis ossificans is slower and more widely distributed and of unknown cause.

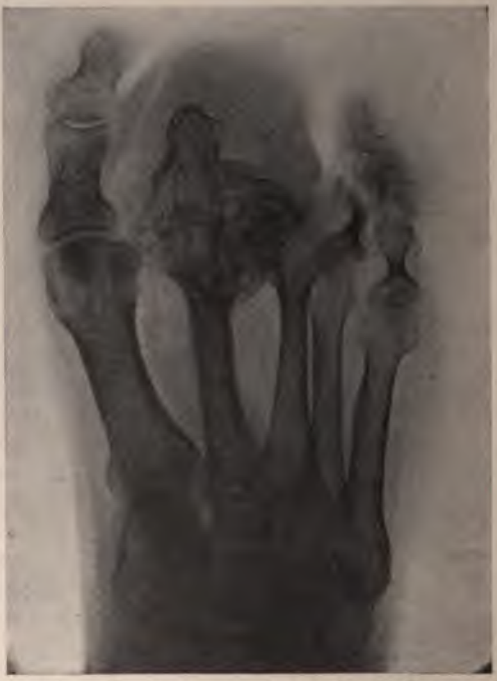


Fig. 98.—Skiagraph of osteoma of second and third metatarsals.

Varieties.—Osteomata are not admixed with other types of tumor tissue, except in cases where soft tumors undergo ossifica-

a. They are almost uniformly made up of bone, and conform one of the types given above.

Pathologic Changes.—Pedunculated osteomata lying in cavi- s occasionally lose their vitality, due to infection or necrosis the pedicle, and are called dead osteomata. Other than the nges due to infection and the rare possibility of sarcomatous rogression, they are not liable to pathologic changes. No nges occur in osteoma eburnum.

Prognosis.—Osteomata are among the most benign tumors. eir location in the pelvis of females may cause difficult or im- ssible delivery of the fetus, or, within the cranial cavity, they y produce fatal pressure.

Treatment.—Unless they cause serious symptoms or produce ious deformity they may be left alone. They are often so ated as to render their removal impracticable. The ivory e can be removed only with the greatest difficulty, unless they removed by excising the segment of bone containing them. unculated tumors should be cut away at the base of the icle.

CHAPTER XXXVI

MYXOMA

Definition.—This is a tumor whose essential structure is connective-tissue cells lying in a matrix of mucin. This tissue is found normally only in the umbilical cord of the fetus, in the vitreous humor of the eye, and in the degenerative changes occurring in the old. It is abundant in the developmental life of the fetus, and is the antecedent of connective and adipose tissue. This tumor, therefore, is closely allied to fibromata and lipomata.

Classification.—Myxomata do not occur in pure form, there being always an admixture of other tissue elements, which will be discussed under varieties. Clinically, they are soft or hard, dependent upon the quantity of mucin, cells, and connective tissue. In connection with the mucous membrane they are spoken of as polyps. The mixed myxomata are distinguished from other tumors suffering myxomatous degeneration. For example, a tumor consisting of an admixture of fatty tumor tissue with myxoma is called lipomyxoma or myxolipoma, while a lipoma undergoing myxomatous degeneration is called lipoma myxomatodes.

Etiology.—Nothing is known of the etiology more than the embryonic theory of Cohnheim.

Structure.—The structure of myxomata is the presence of cells in an intercellular substance (matrix) of mucin, which coagulates in alcohol and shows the acetic acid reaction (microscopically). The cells may be round, spindle, or multipolar. In the latter instance the processes may be extremely long, and seem to anastomose with those from other cells. Giant cells are occasionally observed. The tumor is surrounded by a capsule, from which blood-vessels ramify in varying abundance throughout the tumor.

Sites of Formation.—From what has been said above, it may be easily understood that myxomata may originate in any tissue of the connective or adipose type or in mucous membrane. However, certain sites are marked by especial predilection. Myxomata occur in the nose (nasal polypi) with very great frequency, and occasionally in the uterine canal. In the connective and adipose tissues myxomata are found most frequently in the thigh. The cheeks, particularly at the angle of the jaw, the hand, the back, the breast, the labium majus, and the scrotum are favorite sites. They are seen in the meninges, the brain, and the nerves.

In the nerves they originate in the glia, separate the nerve-fibers, and are spindle shaped. Sometimes they have been seen in the placenta and occasionally in the navel.

Diagnosis.—Myxomata are slow-growing, encapsulated, movable tumors. They occur in the young and middle aged usually, but may be congenital. Many are seen which do not conform to this statement, owing to the fact that they contain sarcomatous elements. The superficial tumors arising from nasal and uterine mucosa are very frequently pedunculated, a feature that facilitates their removal from such cavities. Myxomata are translucent and are soft, resembling lipomata or even cysts in this respect.

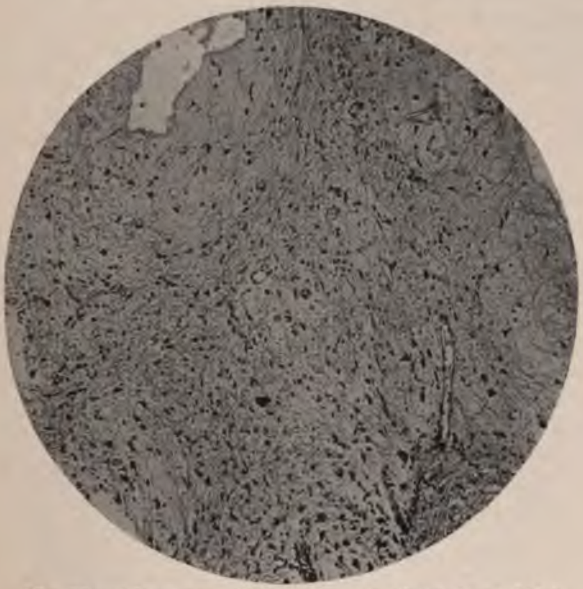


Fig. 99.—Myxoma. (Microphotograph × about 100.)

They may be fluctuant or pseudofluctuant. They are usually small, although instances of individual tumors the size of a fist or even of a cocoanut are reported. They are usually roundish and flattened or elongated by the environing tissues. The surface of small tumors is smooth, but the larger ones tend to have nodular surfaces. They are not painful, but, by virtue of their frequent development in the nose, they cause distress by obstruction, and deformity, if large, and in the uterine cervix they may cause pain and hemorrhage. In the nasal cavity they are often multiple.

Variations.—This tumor is probably not found in the pure type. It is frequently mixed with fibrous tissue, and this is the cause of the increased density in hard polyps, which are more frequently sessile than the softer ones, and, it is said, more likely to recur and become malignant after incomplete removal. They also appear as myxolipoma, myxochondroma, and angiomyxoma or myxoma telangiectaticum. Myxosarcoma is quite a frequent form of malignancy, independently of secondary changes arising in either tumor.

Pathologic Changes.—Cystic degeneration (myxoma cysticum) sometimes occurs, and the assumption of a malignant course is very common; so true is this, that Lexer discusses myxoma under the general subject of sarcoma. Ulceration and hemorrhage occasionally are observed in myxomata of the mucous membrane.

Prognosis.—Encapsulated myxomata are benign and may be removed without danger of recurrence. Care should be taken, however, to remove all the tumor tissue, a difficult matter in sessile hard myxomata arising far back in the nose or from the base of the skull. The tumor returns either as it was or becomes malignant.

Treatment.—Thorough removal by excision or by the snare. Aside from any danger the tumor may possess, polypi should be removed as early as possible after their presence is determined, for, if left in the nose, they cause obstruction to nasal breathing, and, if they attain too large a size to be removed through the anterior nares, require the making of an incision through the face or palate. In angiomyxomata dangerous or fatal hemorrhage may attend incomplete removal, so that in these cases the operation should not be looked upon lightly.

CHAPTER XXXVII

FIBROMATA (FIBROIDS)

Definition.—This tumor has as its essential structure some form of fibrous connective tissue.

Classification.—The term "fibroma," or "fibroid tumor," has been employed very extensively to cover a number of tumors which are not fibromata, such as the so-called fibroid tumors of the uterus, and the present classification is made to embrace pathologic forms that in all probability are not tumors at all. They are

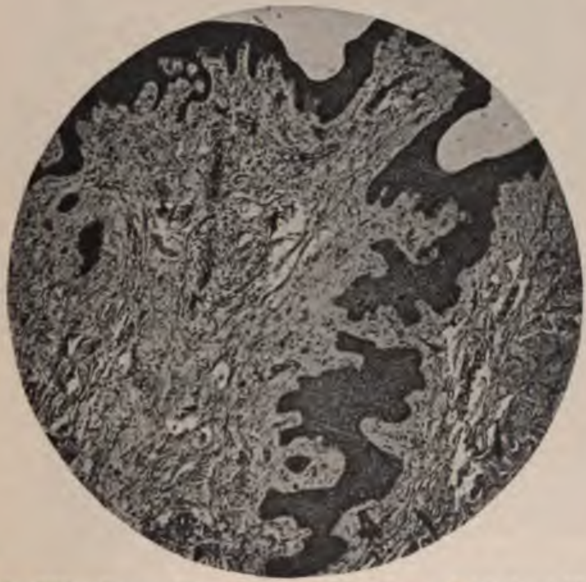


Fig. 100.—Fibroma of skin. (Microphotograph × about 50.)

in this connection for want of a more definite understanding eir true nature. Fibromata are, as a class, subdivisible into na durum (desmoid) and fibroma molluscum. There are all s of density between these two.

e subdivisions which will be discussed in this chapter are (soft warts), fibroma molluscum, keloids, elephantiasis um (lobulated elephantiasis), von Recklinghausen's disease (neurofibromatosis), painful subcutaneous tubercle, epulis and fibromata of the deeper structures, fascia, periosteum, and aponeuroses.

Structure.—The gross appearance of fibroma is that of white fibrous tissue. It may be either hard or soft. The tumor tends to be round and lobulated, the lobules being sometimes attached to the main tumor by pedicles. The cut surface is white and glistening, and yields no juice on scraping. The tumor is distinctly encapsulated. To the naked eye the cut surface may show the disposition of the fibers, which may run with fair regularity, be extremely irregular, or arranged in whorls around the blood-vessels.

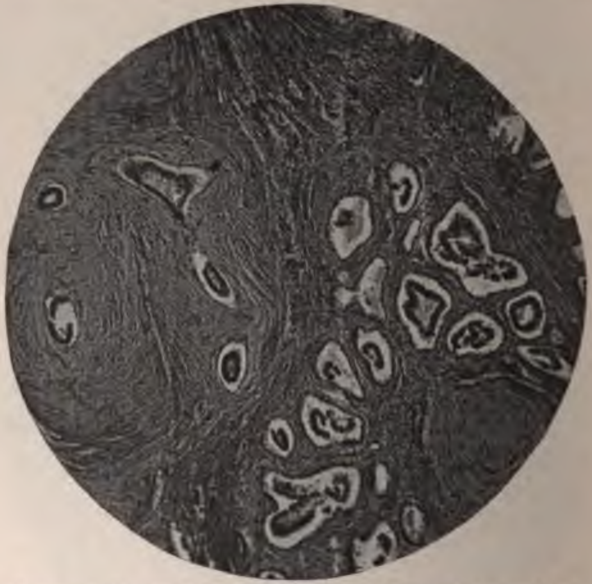


Fig. 101.—Intercanalicular fibroma of breast. (Microphotograph × about 50.)

Microscopically, the essential element is fibrous tissue, with its cells and the nourishing blood-vessels.

Sites of Formation.—The skin is by far the most frequent site of development for fibromata. They occasionally form on the mucous membrane, as that of the nose. The connective tissue in any part of the body may serve as a starting point, the fasciæ and aponeuroses of the abdominal muscles being favorite sites.

The periosteum of the lower jaw, of the upper jaw, and that of the base of the skull furnish the greater number of periosteal fibroids. They are especially apt to develop from the mucoriosteum of the lower jaw. The peripheral nerves are frequently ected by the growth of fibroids.

Diagnosis.—Fibroid tumors possess the usual characteristics benign tumors. They are usually hard, except in fibroma mol-scum, and movable, unless limited by the structure in which ey originate; even then the surrounding tissues can usually be ved in relation to them. The smaller tumors are round and ually smooth, but as they grow in size they tend to become dulated. They may reach an enormous size; on the other hand, ny of them attain a moderate size and cease to grow.

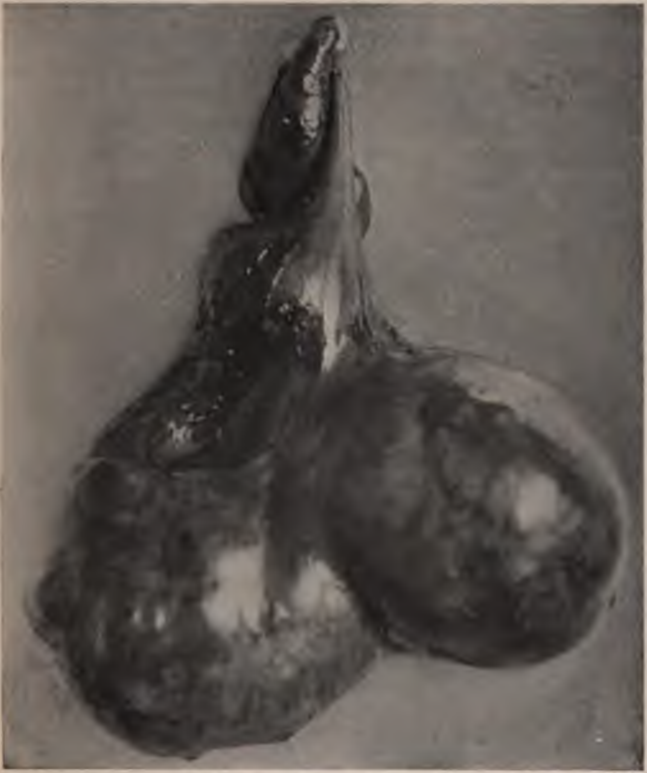


Fig. 102.—Uterine fibroid.

Variations.—Fibrous tissue plays an important part in the con-tution of many tumors, whether epiblastic, hypoblastic, or soblastic. If such tumors, therefore, contain an excess of this sue they are named by prefixing the name fibro- to the name the other tissue. A very common form of mixed tumor is fibro-yoma of the uterus. Owing to the relatively great benignity of fibrous tissue tumors, the other element usually determ largely the nature of the tumor. Fibroma lymphangiectatic possesses the elements of lymphangiectasis plus fibromat tissue. Likewise, fibroma telangiectaticum and fibroma cav nosum are terms used to represent mixed forms of fibroma w angioma and cavernous angioma.

Pathologic Changes.—Fibromata in general are not especia subject to harmful changes. In limited cavities, where subject considerable pressure, they are more liable to infection, inflamm tion, and ulceration, which may be attended with severe hem rhage. This is especially true of fibromatous polypi of the na pharynx, and may occur in subcutaneous fibroids of large si They, especially if submucous, may undergo myxomatous generation, and sometimes cystic degeneration. These chang cause softening of the mass and fluctuation. Calcareous degener tion may be found over the tumor surface, or at points througho its substance, or involves the whole volume of small tumo Naturally this change precludes the possibility of further grow of the affected tissues. If they originate from the periosteu they often show some degree of ossification. Sarcoma does n

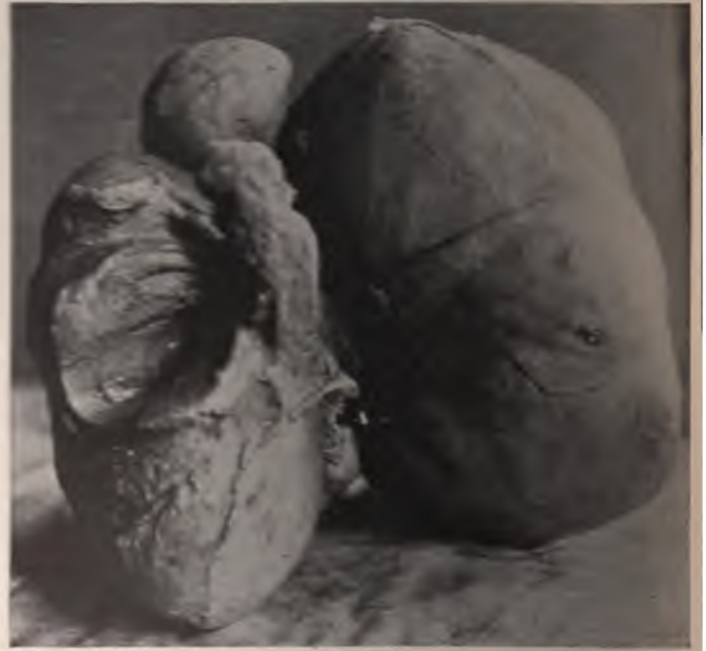


Fig. 103.—Fibroid tumor of the uterus.

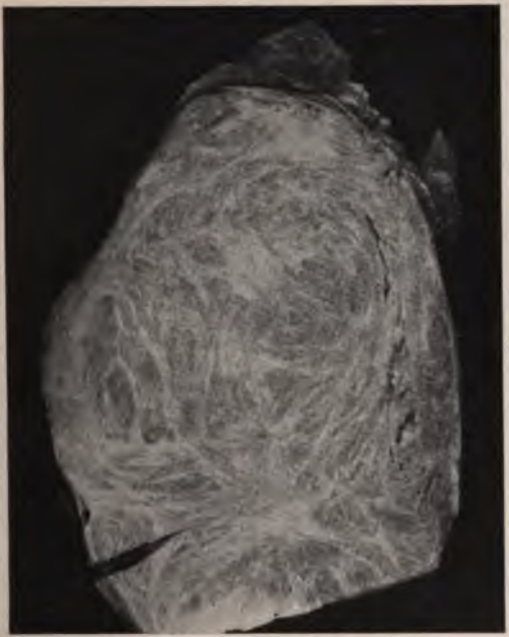


Fig. 104.—Fibroma of ovary.

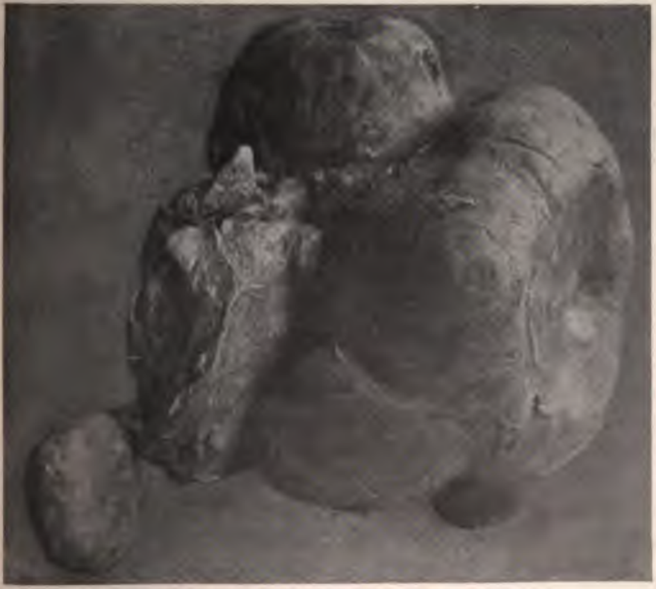


Fig. 105.—Retroperitoneal fibroid.

frequently build upon fibromata in general, but one type of fibroids deserves especial mention in this connection, namely, pigmented moles, which more frequently than any other benign tumor become sarcomatous, particularly if irritated or injured.

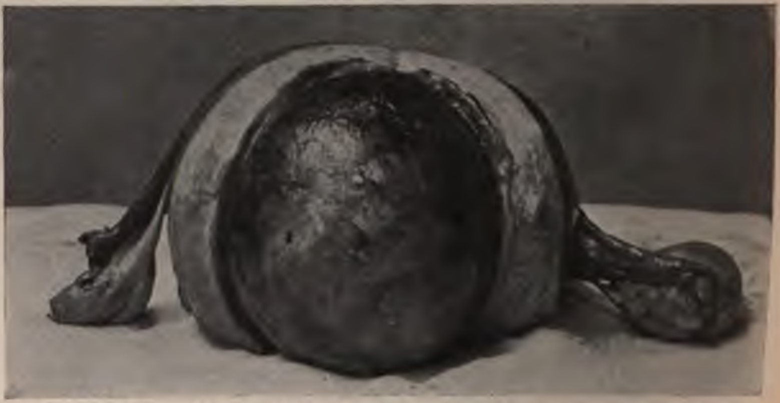


Fig. 106.—Large submucous fibroid of uterus. This tumor apparently caused no menstrual disturbance.

Prognosis.—The life of the individual is rarely lost in consequence of fibromata. They can be removed in almost every instance with positive assurance that no harm will result.

Treatment.—The only treatment is removal.

SPECIAL FORMS OF FIBROMATA

Moles, Soft Warts.—These are by far the most frequent of the skin fibromata. They are frequently pigmented, varying in color from a slight brown to black. They are usually congenital and grow, as a rule, to their maximum size by the time of puberty, although they may increase in size after this age. They frequently are multiple, occasionally scores or even hundreds being observed on a single individual. They may be pedunculated or sessile, and only slightly elevated or notably so, and soft and velvety to the touch. They may be found on any surface of the body except the palms and soles, but have an unquestionable predilection, especially in individuals who have only one or a few of them, for the face, neck, scalp, chest, and shoulders. They vary in size from almost invisible specks to the size of a walnut. They may be flat and cover an area as large as a silver dollar or more. The pigmented moles are covered frequently with dark or black stiff hairs, and possess an excessive number of cutaneous glands and a thicker epithelial coat than the surrounding skin. The surface of these

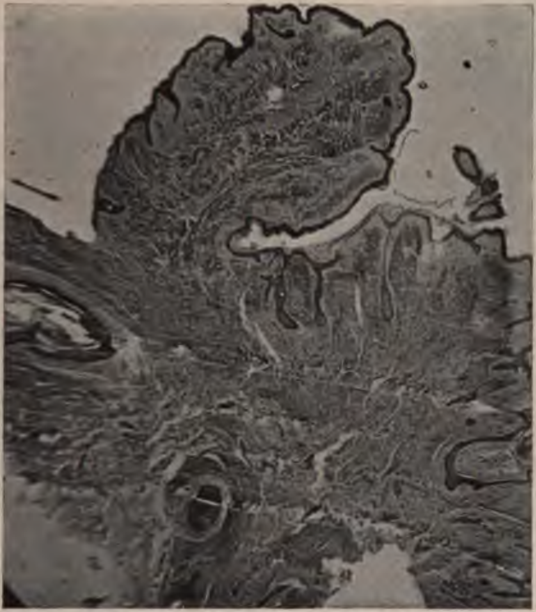


Fig. 107.—Mole. (Microphotograph; × about 100.)

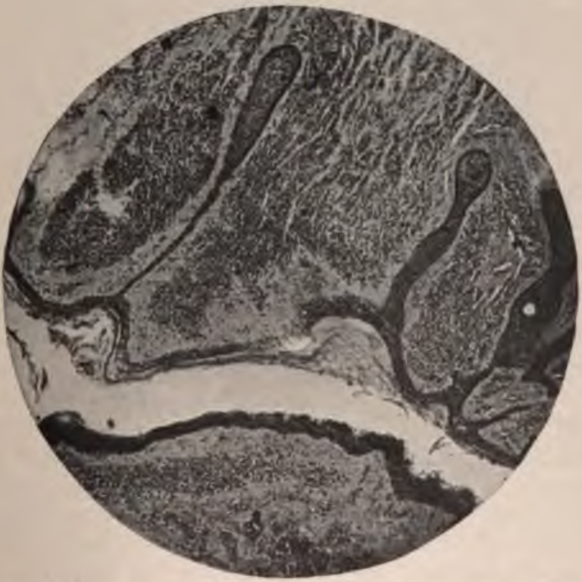


Fig. 108.—Mole. Same as Fig. 107. (Microphotograph; × about 100.)

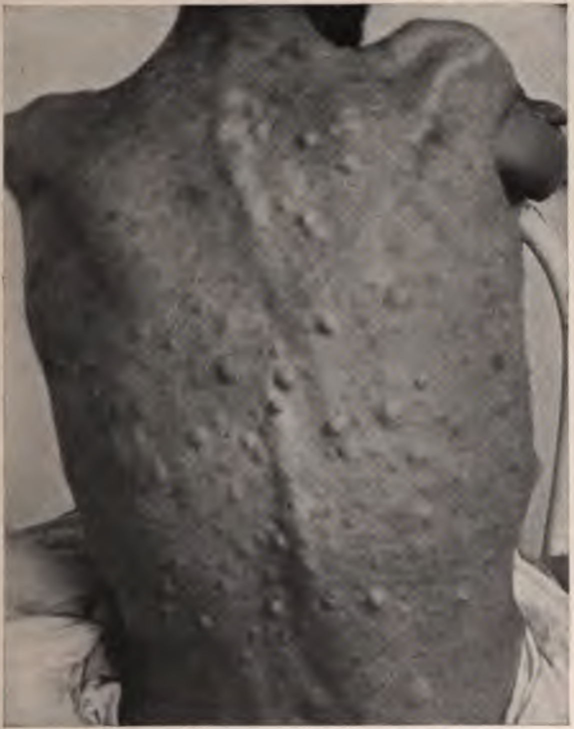
tumors is more or less irregular, roughened, and wrinkled, and may present the appearance of a berry. Moles are more likely to undergo malignant change than any other class of benign tumors. They usually become sarcomatous, occasionally carcinomatous, and in either instance may produce a pigmented tumor, which adds to the malignancy.

The question frequently arises, What shall be done with moles? The answer should be, Deal with them summarily or leave them absolutely alone. If the mole is so situated as to be irritated by clothing or otherwise, its removal is positively demanded; the only advice given by the physician should be in any case to remove them all. If they are numerous they may be removed at several sittings. Partial removal only adds to their danger. Ligation of the pedicle, with a view to strangulation, should never be practised; it leaves the base of the tumor, which may become malignant. Excision of the tumor by elliptic incision or, in the smaller ones, destruction with the galvanic needle or Paquelin cautery are the most approved plans.

Molluscum Fibrosum and Neurofibromatosis.—Molluscum fibrosum (fibroma molluscum or molle) is a condition characterized by the development of soft fibroids in the skin or subcutaneous tissue. They are multiple, of various size, and wide distribution. They may be confined to a single region or be indiscriminately distributed over the body. Molluscum fibrosum is thought to be closely allied to, or even a manifestation of, one form of multiple neurofibromatosis, or von Recklinghausen's disease. The peripheral nerves of the cerebrospinal system are usually affected, but the condition has been seen in the abdominal sympathetic. The nodules may be confined to one nerve, on which a single node or numerous nodes appear, or be general and vary in number from a few scattered tumors to enormous numbers, giving the nerves a beaded or moniliform appearance. In other cases the nerve and its branches are involved for several inches, producing a peculiar network of fibrous tissue (plexiform neuroma). This form is either congenital or appears soon after birth. Again, when the local enlargement is extensive, the tumor masses may grow in such form and position as to cause the skin, often pigmented and hairy, to sag down in folds. They, too, are congenital or acquired in the early years of life. They are found usually on the head and neck, and are often mixed with angiomatous or lymphangiomatous tissue. Owing to their similarity to localized elephantiasis they are called elephantiasis nervorum. According to von Bruns one-twelfth of all cases of neurofibromatosis succumb to sarcomatous changes. Painful subcutaneous tubercle is a small, painful, sensitive neurofibroma occurring on a peripheral nerve

h, usually in the lower extremity, but occasionally in any
of the body. It is movable, hard, and usually about the
f a pea.

reatment.—The treatment of these conditions is removal of
umor masses. There are two contra-indications: first, the
rs may be too numerous, when nothing can be done; or they
involve nerves whose importance is so great that one would
isk the sacrifice of their function, even when grafting or



109.—Neurofibromatosis. The mother, sister, and daughter of this patient all had the same disease.

suture might give good chance of restoration of function.
useless to attempt dissection of the tumor from the nerve-
. The localized tumors in fibroma molluscum and in ele-
tiasis nervorum may be dissected out.

eloid (Cheloid).—As stated previously, this growth is in many
cts unlike a tumor. It is a fibrous tissue growth originating
ar-tissue. The division of keloids into spontaneous and
atic is probably incorrect, all of them being, according to

accumulating evidence, due to traumatism. The extent of the injury and the size of the resultant scar seem to have no influence upon their production; they occur just as readily after small wounds as after larger ones. They unquestionably are influenced by predisposition, which is likely congenital, and may, as in the case of negroes, who have a marked predisposition, be racial. They occur more readily in infected or suppurating wounds than in aseptic wounds, but this is not a *sine qua non*. When an individual once develops a keloid, it is highly probable that under similar circumstances others will develop in the same or in other parts of the body.

A keloid may originate in a scar and confine itself to the original site of that scar, giving it the appearance simply of an overgrown, elevated, hard cicatrix. The needle punctures on either side may each show a small keloid; on the other hand, the most insignificant lesion, which did not even break the upper layers of the skin, or which was of no greater consequence than a bee-sting, the prick of a needle, or puncturing the lobules of the ear for ear-rings, may result in widely spreading growths which attain sometimes the area of several square inches. They seem to be especially prone to follow the excision of sebaceous cysts. They are made up of fully developed tissue, some of whose strands usually are of a hyaline character (collagen) with fibroblasts lying between them. The appearance of keloids is characteristic. They are smooth and glistening; are devoid of hairs, cutaneous glands, and papillæ

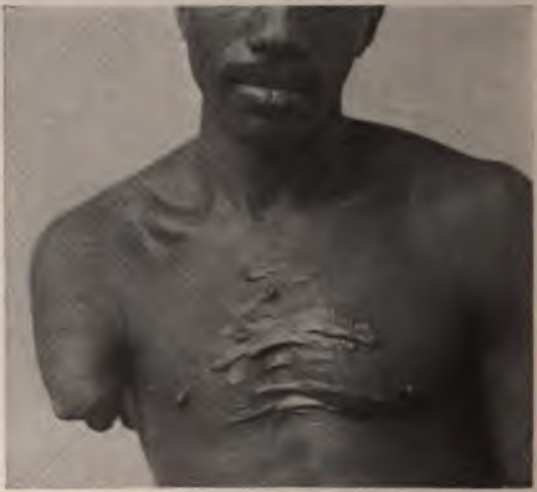


Fig. 110.—Keloid of chest.

over their surface; are hard and are movable over the underlying structures. They often assume bizarre shapes. Keloids are never encapsulated, but at their borders shade gradually away into normal connective tissue. The surface of keloids in the white man is red and remains so, not blanching with age, as in the case of cicatrices. Occasionally a keloid forms in a part of a scar, as I recently saw in an abdominal incision which healed *per primam*. The upper two-thirds of the scar was undergoing normal changes at the end of six months, while the lower third had assumed a distinct keloid appearance. This is to be distinguished from hypertrophied scars, for in the latter, due to infection, the usual changes are observed to follow, while in the keloid continued growth, both in width and thickness, occurs. Usually keloids are painless, but they may cause moderate discomfort from pain and itching. Occasionally, unlike any other mesoblastic tumor, they disappear spontaneously. This is a rare occurrence, and probably has been emphasized by confusion of keloids with excessive scar formation. Again, unlike benign tumors, they tend to recur *in situ* on removal, even when there is no doubt that the whole new formation has been excised. Infection unquestionably renders such recurrence more certain.

Keloids may occur on any surface of the body. They are most frequently seen on the face, neck, upper arm (following vaccination), shoulder, anterior surface of the chest, and the dorsum of the hand. They are rarely observed on the palms and soles.

Treatment.—The treatment of keloids is very unsatisfactory from an operative standpoint. They may be safely removed, but promise cannot be made that they will not return. For several years in succession we used the same woman in the clinic of the Medical Department of Vanderbilt University, removing keloids from the ear-ring punctures, a tumor from each end of both punctures. *x*-Rays give probably the best results so far. Thiosinamin injected directly into the tumor substance, 10 to 15 minims of a 15 per cent. alcoholic solution being injected at each sitting, causes reduction in size, but cannot be said to cure.

Epulis.—This is a tumor originating from the periosteum covering the alveoli of the jaws. It is made up of fibrous tissue which often contains giant-cells (hence its frequent classification with sarcomata). The tumor may contain bits of new-formed bone. It develops in both the upper and the lower jaw, much more frequently the latter, is much more common in females, and usually in the anterior portion of the jaws (not further back than the first molar). They originate in the periosteum at the neck of a tooth, between two teeth, or from a tooth socket. They are pedunculated or sessile, rarely attain great size, being no larger than a pigeon's egg. If the tumor originates between two teeth it will often found protruding both from the lingual and the buccal si

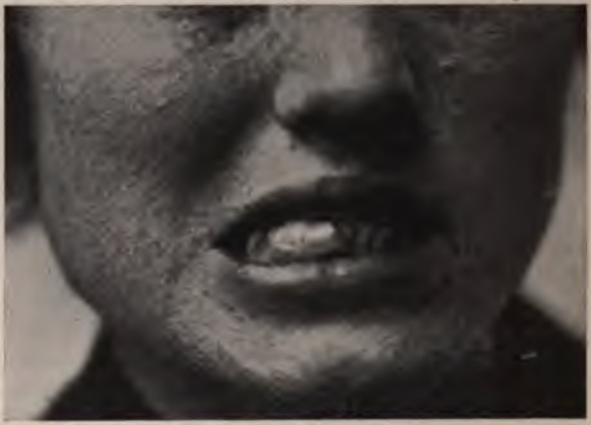


Fig. 111.—Epulis in a girl aged seventeen years.

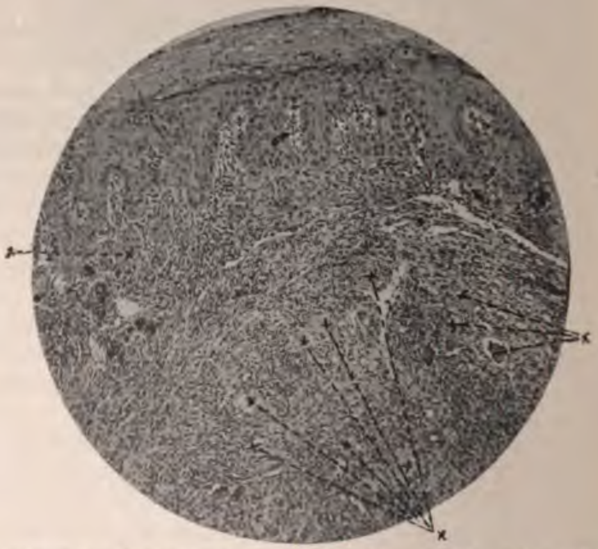


Fig. 112.—Epulis. Giant-cells at x showing throughout. (Microphotog × about 100.)

They may be soft or hard and are covered with mucous memb and are smooth or slightly nodulated or berry-like, unless are ulcerated. They are benign in their behavior in most stances, although the giant-celled type seems to be justly given as a subdivision of sarcoma. They cause separation or deviation of the teeth, interfere sometimes with mastication, and are unsightly if in the incisor region.

They recur when removed by application of cauterizing agents, active or potential, and can be relieved only by excision of the periosteum from which the tumor arises. This frequently necessitates, unfortunately, the extraction of the teeth between which the tumor grows. It is seldom necessary to remove a portion of the alveolus, as the tumor is usually of periosteal origin, but if it is bony it becomes necessary to remove a portion of the alveolus.

CHAPTER XXXVIII

LIPOMA

Definition.—A lipoma is a tumor whose essential structure is fatty tissue.

Classification.—Lipomata are usually of the simple encapsulated variety. However, the capsule may be incomplete, allowing finger-like processes to project from the body of the tumor into the joints, and called lipoma arborescens; they arise from synovial villi and external to the pleura and peritoneum. A third variety appears as a large fatty mass accumulated in the subcutaneous connective tissue, and spoken of as a diffuse lipoma; it has no semblance of a capsule. The latter probably do not deserve to be classed as true lipomata; they are rather subcutaneous accumulations of fat, and are seen usually beneath the chin, in the axilla, and over the lower abdomen.

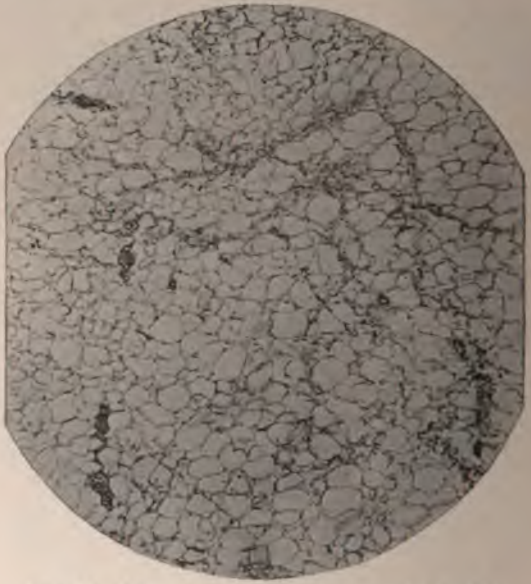


Fig. 113.—Lipoma. (Microphotograph; × 40.)

Xanthoma or *xanthelasma* deserves to be mentioned here, not as a subdivision of lipomata, but because it is a small tumor-like mass whose nature and etiology are not understood; it is sometimes seen in diabetics.

Etiology.—How important a part trauma plays in the causation of lipomata is uncertain. Undoubtedly they do sometimes follow prolonged irritation of the subcutaneous fat by pressure, as is seen in those who carry heavy loads; this is probably only incidental, and the majority come independently of outside influences. They are occasionally symmetric, which would suggest trophoneurotic influence. The so-called arborescent lipomata of the large articulations frequently are associated with tuberculosis of the joint or with arthritis deformans.

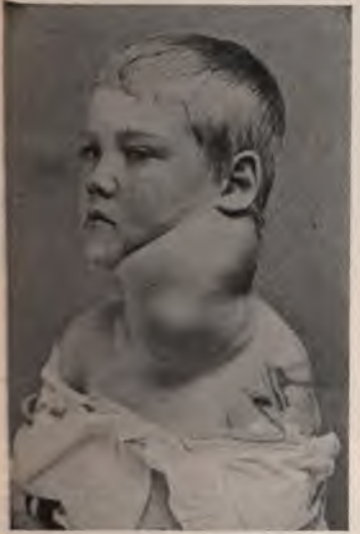


Fig. 114.—Lipoma of child's neck.

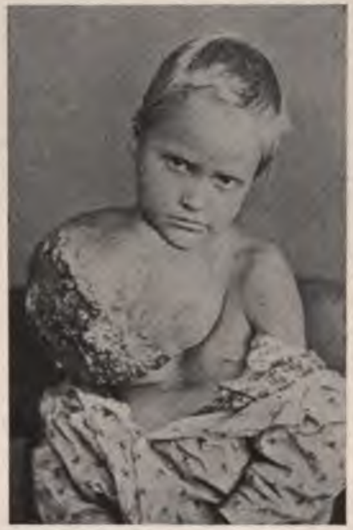


Fig. 115.—Ulcerative lipoma in a child. Weight of tumor, 8 pounds.

Structure.—The fat of lipomata cannot be easily distinguished from normal fat. It is paler, and the cells are larger than in normal fat (Adami). The tumors are usually encapsulated with a thin but definite capsule. The fat is supported, and the lobes and lobules are separated, by a connective-tissue framework just as in normal fat, and the blood-vessels are conducted along these septa.

Sites of Formation.—The vast majority of lipomata arise in the subcutaneous fat, the neck, shoulders, back, and hips being the most frequent sites. They may occur in any region of the body, even appearing rarely in the palms (beneath the palmar fascia) and the soles. They are rare in the subcutaneous fat of the scalp. In the deeper regions of the body (subaponeurotic) lipomata develop much less frequently. They are sometimes seen arising beneath the occipitofrontalis muscle and aponeurosis. In the abdominal wall, the pectoral region of the chest, the neck, and the thigh are found the majority of intermuscular (subfascial) lipomata. Occasionally they develop in the cheek from the sucking cushion. In the extraperitoneal fat and in the perinephric fatty capsule fatty tumors may arise which often attain enormous proportions. The same may be said of the mesenteric fat. The lipomata found surrounding the sac of inguinal and femoral herniæ belong to the extraperitoneal group. Often there is, in cases

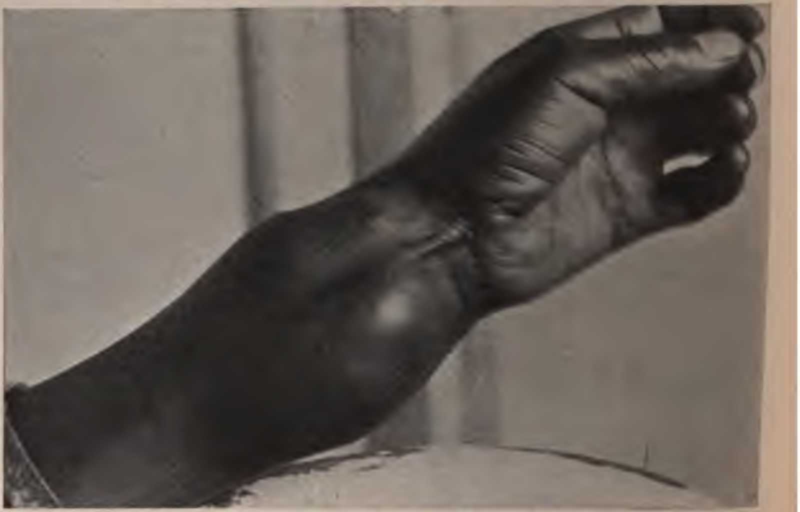


Fig. 116.—Lipoma of forearm, lying beneath vessels, nerves, and tendons.

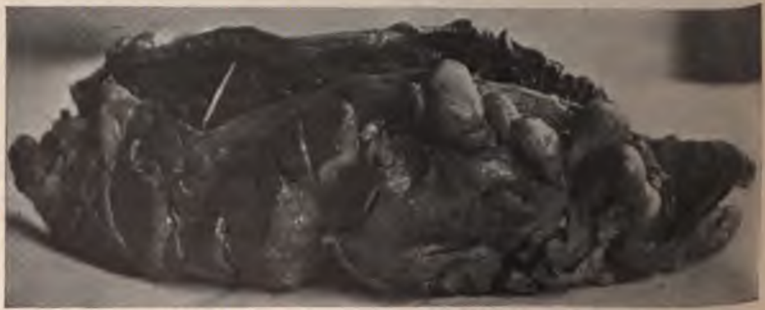


Fig. 117.—Lipoma of mesentery. Note the opened intestine at top.

of hernia, an excessive quantity of fat covering the sac, and in a few cases it makes a rather large tumor. The fatty tumors found in the kidney, brain, and meninges are usually small, but in the kidneys they may rarely attain great size.

Diagnosis.—Lipomata are usually easily recognized if they are subcutaneous tumors, and will not often be confused with other enlargements in the subfascial and extraperitoneal sites if the usual points of development be remembered. They appear as single or multiple, occasionally numerous, tumors, sometimes symmetric. They vary in size from insignificant lumps the size of a bean to a mass of 50 or 60 pounds, although at the present day individuals usually have them removed before they reach great size. They usually appear at some time between the twentieth and fiftieth year of life and grow slowly and steadily; occasionally one stops its growth for a time without known cause, later continuing again. They are flattened or roundish tumors, resembling usually an inverted saucer beneath the skin. They are thoroughly movable, both in relation to the skin and to the underlying structures. The skin over the surface is smooth and normal in appearance, except for the unevenness produced by lobulation, which may be very distinct. An attempt to lift the skin away from the tumor usually results in the so-called dimpling, or retraction, of the skin at points where the capsule is attached to the skin by connective-tissue bands. The consistency of fatty tumors is described as being doughy or that of wool packed into a sac. In the larger tumors fluctuation may be so apparent as to lead one to the diagnosis of a cyst, especially if the tumor is deeply seated. Pseudofluctuation is present even in moderately small tumors. By pressure on the surface of the tumor its soft lobules can usually be felt. Pressure on the edge of the tumor (the flattened form) causes the tumor tissue to escape suddenly from the grasp, much as moist orange pits are thrown by compression between the thumb and forefinger. Lipomata are usually sessile, but may, as they grow, gradually become pedunculated. When situated under a vertical surface, especially on the back, they may gradually gravitate to a lower level, so that after a time they assume an entirely new position. Application of ice to their surface causes hardening of the mass. Emaciation of the individual does not alter the course of lipoma to the same degree as normal fat. The nature of extraperitoneal lipomata and those occurring in the perinephric fat is rarely recognized until they are cut down upon.

Variations.—Lipomata may contain a large proportion of fibrous tissue, showing only small bits of fat scattered throughout (fibrolipomata). These, of course, show less the characteristics of fatty tumors. They are harder than the ordinary lipoma. Rarely bits of cartilage or bone are found in these tumors. It is questionable whether these masses represent a mixture of types or metaplasia. Exceptionally a lipoma contains a large supply of blood-vessels (lipoma telangiectaticum). Myxomatous lipoma, or myxolipoma, is also rarely seen; it is characterized by the presence of myxomatous tissue in the stroma of the tumor.

Pathologic Changes.—Lipomata are not frequently altered by accident or disease. They are the least harmful probably of the tumor group. The fatty tissue may become edematous and degenerate, leaving an accumulation of oil in pockets throughout the tumor, known as oil cysts. Mention has already been made of the occasional appearance of bone or cartilage. Calcification of the tumor may occur, due to the deposit of lime salts in the connective tissue. Necrosis and ulceration are sometimes observed in a portion of the tumor. Inflammation may develop and cause the general appearance to become very like sarcoma. The history of an old tumor, and of recent infection or traumatism, and the ensuing signs of inflammation, are the important features in differentiation. Lipomata are the most benign of tumors, yet rarely sarcomatous changes occur, with the usual evidences of sarcoma.

Prognosis.—The outlook for an individual who has a lipoma is good. The tumors can be safely removed and do not return. If incomplete removal is done in diffuse lipomata the portion left in the tissues will probably continue to grow.

Treatment.—Lipomata should be removed when recognized. They will usually continue to grow and, especially if large, become complicated and possibly malignant. Owing to their subcutaneous position and the size they may attain, it is often better to excise an elliptic piece of skin with the tumor to insure better closure of the wound.

CHAPTER XXXIX

ANGIOMA (HEMANGIOMA)

Definition.—An angioma is a tumor made up of new-formed blood-vessels.

Classification.—Three types of angiomata are given, namely, *capillary* angioma (nevus, port-wine stain, birth-mark), *cavernous* angioma, and *plexiform* angioma (cirsoid aneurysm). The latter probably does not belong in the group of angiomata, as Adami was unable, in a thorough study, to find evidence of new-tissue formation, and he thinks the condition is due to a congenital weakness of the vessels rather than to tumor formation, as, indeed, he considers most of the so-called angiomata to be telangiectases.

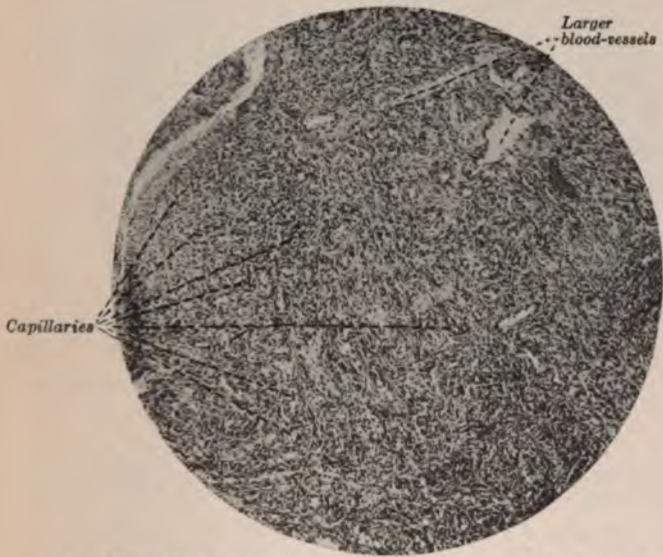


Fig. 118.—Capillary angioma. (Microphotograph; × about 100.)

Etiology.—The majority of angiomata are congenital, although they may at the time be almost or altogether invisible. Others arise in infants during the first or second year of life. It should be remarked here that many children show red splotches, especially at the glabella and the nape of the neck, which disappear permanently during the first or second year. Plexiform angiomata develop independently of any known cause as a consequence of irritation or trauma, but usually from a pre-existing angioma. Arborescent varicosities are the result of obstruction or senile changes, and sustain no relation to tumors. Certain angiomata seem to be produced, or influenced at least, by disturbances of the nerve-centers.

Structure.—Angiomata represent an excessive production of permanent vascular tissue: in the capillary type enlargement and multiplication of capillaries, in the cavernous type large vascular spaces or caverns. The types are often mixed. The capillaries of the first type are dilated and extremely numerous. They run from arterioles to veins, and are unevenly distributed and separated by connective tissue. The endothelial lining is frequently several layers thick, and the structure of their walls resembles that of the arterioles. The cavernous type is made up of caverns which are filled with blood and communicate with the general circulation. The septa forming the partitions may contain blood-vessels which appear normal. The structure of plexiform angioma is simply an increase in the length, diameter, and tortuosity of the vessels, with thickening of the vessel walls.

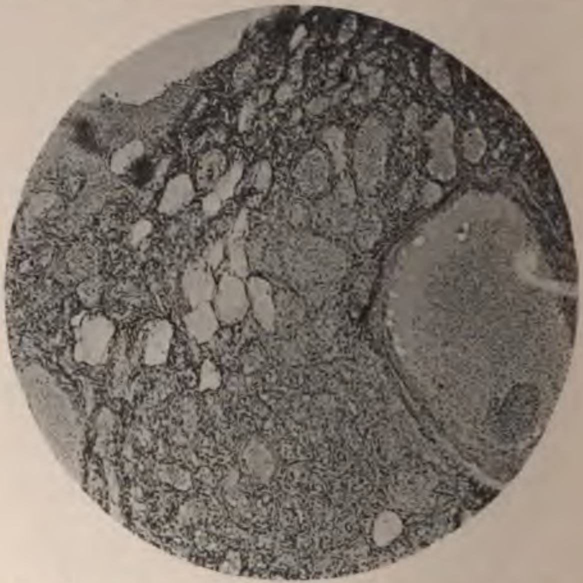


Fig. 119.—Cavernous angioma. (Microphotograph; × about 100.)

Sites of Formation.—Capillary and cavernous angiomata are found especially on the face, head, neck, and hands, occasionally on the trunk and the extremities. Much more rarely the mucous membrane of the mouth and tongue, the larynx, the bladder, or the uterus show them. The deeper structures are sometimes affected, as the salivary glands, the breasts, the muscles, especially the large muscles attaching the humerus to the scapula; and, finally, the viscera are very infrequently affected, as the liver, kidneys, spleen, and intestines. The confinement of angiomata to the distribution of a certain nerve or group of nerves is very interesting. The distribution of the fifth nerve, especially the first and second divisions, is especially affected. In some of the nevi in the distribution of the fifth nerve it is known that a corresponding vascular condition affects the dura; to what extent this statement holds true is not yet known. Plexiform angiomata are usually found in the branches of the anterior division of the superficial temporal artery, and often affect anastomosing branches from collateral vessels. Other arteries of the scalp are sometimes affected. The site next in frequency is the upper extremity below the elbow.

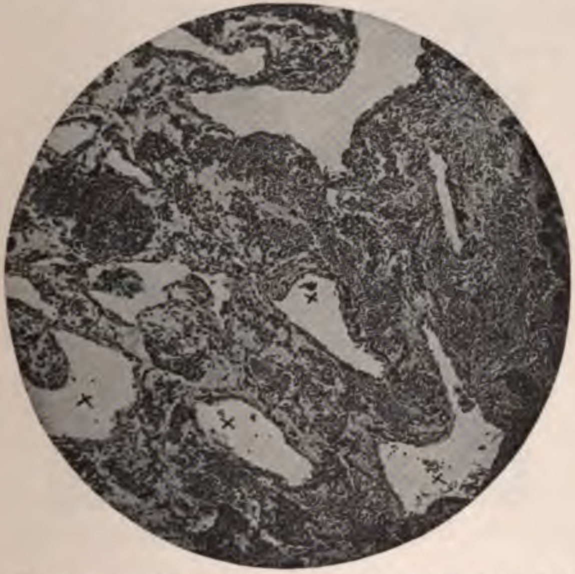


Fig. 120.—Cavernous angioma. The blood has been largely washed out in the process of staining; a few cells, however, are seen at *x*. (× about 100.)

Diagnosis.—As stated already, angiomata are usually congenital; this is by no means an absolute rule. If not congenital, they usually appear in early life. The "port-wine stain," when purely capillary, is recognizable only by the discoloration. Its surface may be on a level with the surrounding skin or slightly but perceptibly elevated. It may vary in size from a pin's head to enormous dimensions, covering an area of half the face, scalp, and neck, a whole extremity, or nearly one-fourth of the body surface. The color of a birth-mark varies with the rate of replenishment of its blood; hence, it may be a bright red, bluish, purplish or a dark blue, almost black. They are symptomless. The size at birth may slowly increase, *pari passu* with the normal development of the child, or the growth may be rapid, so that a previously insignificant mark may in a few months become extensive. The growing capillary nevi often assume the mixed type, and the tumor becomes nodular in appearance and produces the grossest disfigurement by thickening the lips, the cheek, or the eyelids, even to complete closure. Pressure on a capillary angioma forces the blood away and shows a normal flesh color, but instantly the pressure is released the blood rushes again into the vessels. They are occasionally associated with an excessive growth of hair.

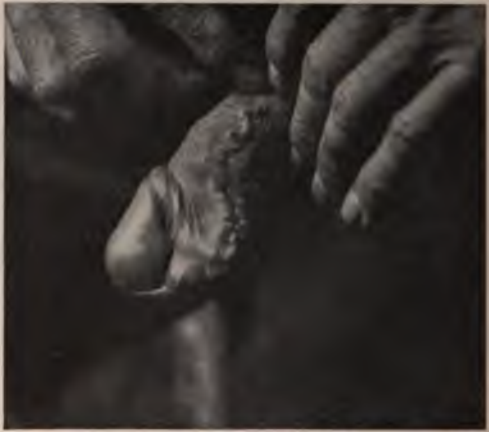


Fig. 121.—Cavernous angioma of prepuce.

Cavernous angiomata are soft, non-pulsating tumors, visible and palpable, fluctuant and collapsible by uniform pressure. They may be no larger than a pea or as large as a cocoanut, and mixed with capillary angiomata or altogether independent of involvement of the tegumentary capillaries. If there is no associated nevus the tegument covering the tumor may appear of normal color; however, if the blood caverns lie close to the skin the bluish color of the underlying blood may be seen. Crying, straining, or holding a deep inspiration increases the size of the tumor. In uncertain cases aspiration with a fine needle brings forth pure blood. Aspiration in suspicious cases should always be done with the smallest needle, inserted obliquely. They often grow with extreme rapidity, adding new caverns or enlarging the ones already present. Cavernous angiomata cause absorption of the tissues in relation with them, even the foramina of the emissary veins which communicate with such tumors may be many times the normal size. Both capillary and cavernous angiomata are benign, and the true telangiectases, which many of the tumors doubtless are, have no new tissue elements in their make-up. Capillary angiomata admit moving of the skin normally over the underlying structures, and the cavernous type may be surrounded by a fairly distinct capsule, although the majority of them doubtless want it.

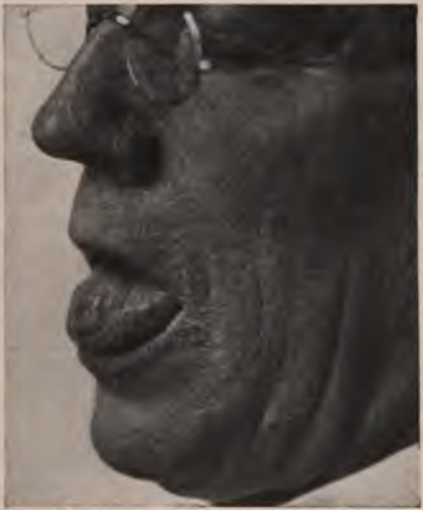


Fig. 122.—Cavernous angioma of the tongue in a man seventy years old. The growth is congenital.

Angiomata in the skin supplied by the fifth nerve may have an associated angioma of the dura, which occasionally produces formidable complications, as epilepsy, or even sudden paralysis or death from acute hemorrhage within the cranium.

Plexiform angiomata cannot be well confused with another condition. The presence of numerous dilated, tortuous, pulsating arteries associated with or independent of previous capillary angioma, especially the red ones whose circulation is rapid, leaves no chance for error. The bones which lie in contact with such vessels are grooved and tunneled by the constant pressure.

Occasionally an angiomatous part is extremely hypertrophied or overgrown. A lower extremity, for example, affected by an extensive capillary angioma shows sometimes considerably larger than its fellow.

Cavernous angiomata in the mouth may become so large as to render eating difficult and conversation impossible.

Variations.—Angioma frequently appears in mixed tumors, as angiofibroma, angiolipoma, angiosarcoma, and angiolymphangioma. The angiomatous element frequently escapes notice until operation is begun. The appearance of the various types of angioma in a single tumor has been sufficiently discussed.

Pathologic Changes.—The disappearance of certain capillary angiomata has been mentioned already. It is due to the proliferation of fibrous tissue and the consequent obliteration of the vessels. Even capillary angiomata of considerable size may be thus destroyed or reduced in extent. Inflammation, ulceration, and hemorrhage may occur more readily, it will be understood, in those whose circulation is slow. Injury is likely to cause profuse or fatal hemorrhage unless pressure is applied, which easily accomplishes the purpose, except in the plexiform type. Sometimes wart-like elevations appear over the surface of an angioma, and in others a fibrous-tissue hyperplasia occurs between the blood-vessels, giving the part the likeness of elephantiasis, *elephantiasis hæmangiomatosa* (Kauffmann). Phleboliths are sometimes seen; angiomata rarely if ever become sarcomatous; epithelioma sometimes arises over the tumor surface, but it is in all probability independent of the angioma.

Prognosis.—The prognosis of angiomata is good unless they begin to bleed; they then become dangerous. They cause disfigurement, and in the mouth or about the eye interfere with function. They are frequently safer left alone than operated on, owing to the danger from hemorrhage. Therefore, rapid growth in small tumors should always be a positive indication for immediate treatment. Those affecting the dura are dangerous because of pressure and possible hemorrhage. Recurrence is often seen.

Treatment.—The treatment of angiomata in general may be summed up in the statement that the vessels should be obliterated or removed. In very young infants who have slight nevi it is best to observe them for a time, as many will disappear; the diminution in size or color is encouragement to wait still further.

When it is possible, owing to the size, situation, and type of the tumor, excision is the best plan of treatment; but, unfortunately, many of the most disfiguring tumors are not amenable to this plan if they are large, as the resultant defect would be worse than the original. Small tumors, either capillary or cavernous, may usually be excised. Cavernous angiomata in loose connective tissue and in the fat may be excised. In all instances where an attempt at excision is to be undertaken, the utmost care should be exercised to avoid incising or tearing into the tumor tissue, particularly if cavernous, as alarming or fatal hemorrhage may result. The vessels supplying the tumor should be double ligated as they are approached, and it must be understood that many of these are dilated far in excess of their normal size, partaking of the same changes found in the tumor. If any of these vessels make their exit from bone and immediately enter the tumor, which occurs in cavernous angioma of the scalp, they can frequently be controlled only by use of the actual cautery. If it is necessary to remove an angioma on account of its interference with function, and if removal is impossible without cutting through the clump of vessels or caverns, the first step of the operation should be ligature of all important arteries and veins communicating with it.

Superficial capillary angiomata may be satisfactorily dealt with without cutting. The more the cavernous element is present, the less applicable the plan. The most satisfactory plan, perhaps, is to freeze the surface through the whole thickness of the tumor with carbon-dioxid snow. The depth to which the freezing reaches is determined by the number of seconds of application and the firmness of pressure, which cuts off the circulation from the area under treatment. If the tumors cover a large surface, several sittings should be had. The use of the galvanic needle in angiomata of considerable size is a worthless form of torture, for the patients become disgusted and leave off their treatment long before it is finished, as witness the large number of old angiomata dotted with little islands which represent the sites of puncture.

Cavernous angiomata that cannot be removed by dissection may be cured by the injection of boiling water directly into the tumor mass. An ounce is a sufficient dose, and when the clot has absorbed the injection may be repeated at a new point. Care must be taken not to burn the skin, as sloughing and possible hemorrhage will result. The procedure produces little or no pain unless the skin is burned. The dangers of this method theoretically are embolism and infection, although I know of no instance of either.

Plexiform angiomata present a difficult and often unsolvable problem. They may be treated best by ligating all the feeding arteries and removal of the dilated vessels. If this cannot be done the tumor had best be left alone. In determining whether to excise or leave plexiform angiomata, the first question to decide is whether the vessels can be spared without sacrifice of the tissues they supply. On the extremities amputation may be required.

CHAPTER XL

LYMPHANGIOMA

THIS tumor is made up essentially of new-formed lymph-spaces and channels. It sustains, in a sense, the same relation to the lymphatics that angioma does to the blood-vessels, with this important exception, namely, that the new-formed vessels and spaces in lymphangiomata do not communicate, at any rate freely, with the normal lymphatics. The same difficulty is encountered here as in angiomata, on account of the presence of lymphangiectases, which cannot be regarded in any true sense as tumors.

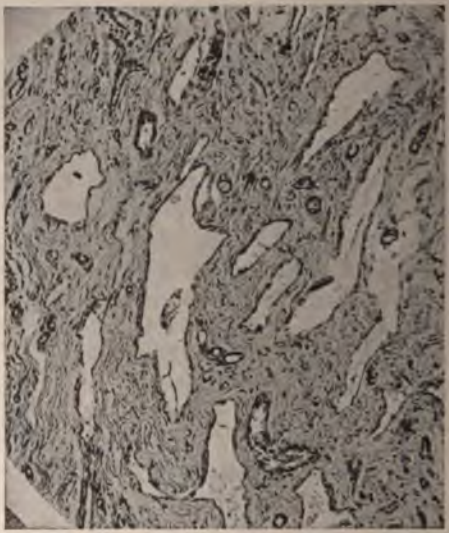


Fig. 123.—Lymphangioma. (Microphotograph; × about 100.)

Classification.—There are three distinct types of lymphangioma. First, *simple lymphangioma*, which is made up of lymphatic vessels, large and small, bound together into a bundle or mass. In this type the vessels may be more or less dilated, but not to the degree found in the second class. There are all degrees of gradation between the first and second types. Second, *cavernous lymphangiomata*, which are spongy masses of caverns and spaces held together by connective tissue and muscle-fibers (unstriped), and separated from each other by septa which constitute their walls. The most frequent examples of the cavernous type is seen in macrocheilia and macroglossia. Third, *lymphangioma cysticum* or *cystic hygroma* (hygroma cysticum colli congenitum) is the most interesting type in many respects. It is made up of a large number of cysts of varying sizes and independent of, or communicating with, each other.

Etiology.—The vast majority of lymphangiomata are of congenital origin, like angiomata, a fact which points to their cause in the majority of cases as imperfect or misdirected development, rather than to an origin similar to that of other tumors and

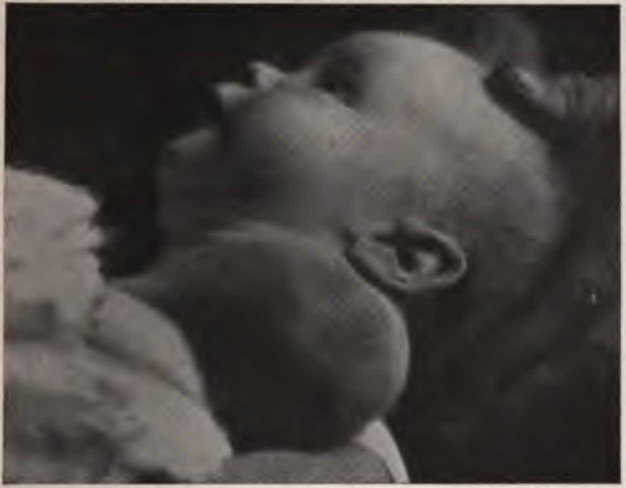


Fig. 124.—Cystic hygroma of the neck in a child two months of age.

equally obscure. Postnatal lymphangiomata do arise even as late as the menopause, and they may develop subsequent to, and at the site of, a recent trauma, if not as its direct consequence. Some lymphangiomata are unquestionably of new formation, but most of them are due to obstruction or developmental disturbances, and appear usually at sites where fetal fissures and clefts have closed.

Structure.—The tumors are made up of the various spaces described above, lying in the midst of a connective-tissue framework and lined with endothelium. They contain a clear fluid (lymph), or in the cystic type it may be clear, turbid and milk-like, or chocolate brown, and show the presence of débris and cholesterin. The dark discoloration is due to the escape of blood into the cysts.

Sites of Formation.—Single lymphangiomata are found essentially in the skin and in subcutaneous tissues, most frequently in the face and neck. Cavernous lymphangiomata are usually seen as congenital malformations of the lips, *macrocheilia*, or of the tongue, *macroglossia*, in which organs they may produce most disfiguring and harmful lesions. Other regions may be affected by this type. The cystic type is found most frequently in the neck, and may extend as low as the clavicle or as high as the ear or the ramus of the jaw. They sometimes appear also in the region of the shoulder, the axilla, the abdomen, the sacrum, and the groin. They are rarely found in the mesentery, and in this location they contain a chyle-like fluid.

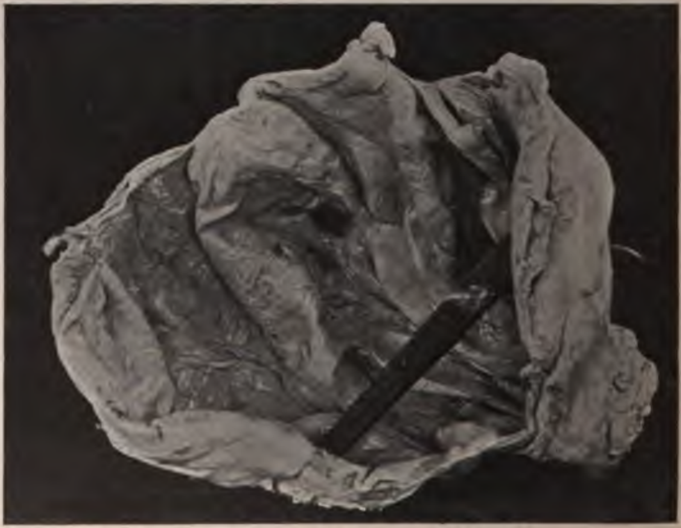


Fig. 125.—Sac of large axillary cyst. Cystic hygroma.

Diagnosis.—The majority of lymphangiomata are congenital, although, as already stated, some may arise in advanced life. The simple form appears usually as a diffuse tumor, with little or no evidence of encapsulation; the cavernous type also is diffuse. These two, therefore, will rarely be found as distinct tumor masses independent of the tissues of the region, but rather as invading the structures, producing an apparent hypertrophy of the part. The cavernous tumors sometimes form a distinct mass, which is poorly circumscribed. They constitute soft, flabby, elastic tumors, and have a consistence resembling that of lipomata. Macrocheilia and macroglossia may be of such dimensions as to produce the most hideous deformity, the tongue being so greatly enlarged as to protrude from the mouth and preclude the possibility of speech and mastication and produce marked discomfort. The cystic variety may reach an enormous size, especially when it is considered that they are found in infants, in whom they may frequently attain the size of an orange, and occasionally become almost as large as a child's head. Some of these cystic tumors fail to grow for a long period of time, and later, even in adults, may grow rapidly to troublesome dimensions. They may be fluctuant or not, dependent upon the size of the individual cyst cavities and the amount of connective tissue separating them and their distribution among the normal anatomic structures. The cyst shown in Fig. 124 was fluctuant, but, on attempting to dissect it away, the whole side of the neck was found to be filled with smaller cysts lying around the great vessels, among the nerves of the cervical and brachial plexuses, and in the intermuscular spaces deeper than the scaleni. The cystic variety is distinctly translucent if transillumination can be done, unless the fluid happens to be opaque. They are to be distinguished from cysts occurring in the neck in vestiges of the gill-slits. The latter are lined with epithelium, are single, simple cysts, and do not invade the structures surrounding them.

Variations.—There is frequently present in other benign tumors an excessive quantity of lymphangiomatous tissue, and it may be abundant enough at times to justify the name of a mixed tumor. They are especially liable to be mixed with angioma.

Pathologic Changes.—Changes are not frequent. When a simple or cavernous lymphangioma is wounded there may be a copious discharge of lymph which continues for an indefinite time.

Prognosis.—Of themselves they cause no harm. Situated in the neck or pharynx, in the mesentery or the pelvis, they may be responsible for serious interference with physiologic processes, and in the region of the neck and pharynx may cause sudden death. The cystic hygromata occasionally disappear spontaneously. They do not become malignant.

Treatment.—The ideal treatment of lymphangiomata, as in other benign tumors, would be excision. Manifestly, from the diffusion of the tumor mass such treatment is often impossible. In that case, contrary to the general rule in benign tumors, one may remove as much of the tumor as possible, with no fear on account of the portion left; or in those cases like macroglossia and macrocheilia, where an anatomic structure must be reduced in size, such reduction is accomplished by excising portions of the tongue or lip, regardless of the amount of lymphatic tissue or muscle removed. If the growth continues the treatment must be repeated.

CHAPTER XLI

MYOMATA

Definition.—A myoma is a tumor whose essential tissue is muscle-fiber.

Classification.—There are two types of myoma—namely, *leiomyoma*, which is made up of unstriped muscle tissue, and *rhabdomyoma*, whose muscle-fibers belong to the striped or voluntary variety. The latter is a very rare form, so rare, indeed, that certain authors have disputed its existence, while the former is very common, although they do not appear without the admixture of connective tissue, frequently of other tissues. This, however, is in a sense true of practically every tumor, benign or malignant.

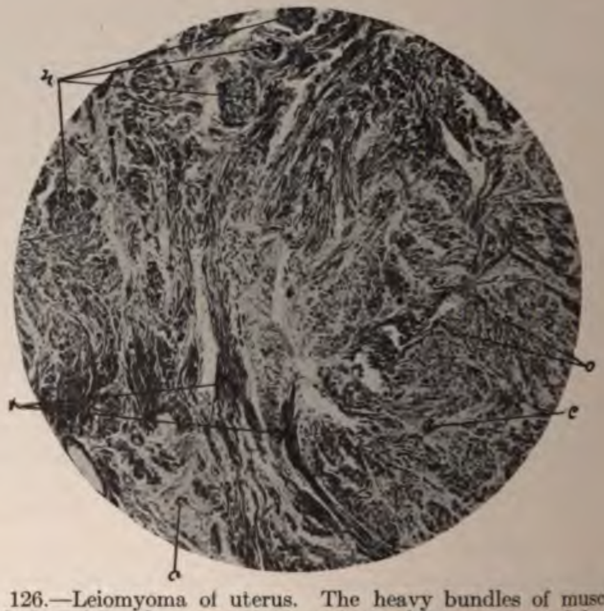


Fig. 126.—Leiomyoma of uterus. The heavy bundles of muscle-fibers are seen in long (x) and transverse (o) section and in separate nodules (n) and connective tissue (c) between. (× about 100.)

Etiology.—The fact that the appearance of myomata, especially in the uterus, is more frequent than that of any other tumor has added nothing definite to our understanding of its cause. Cell-rests have not been discovered. It has been supposed to occur less frequently in women who have borne children; the converse statement is probably nearer the truth—namely, that women who have uterine tumors do not, as a rule, become pregnant, as these tumors are one of the *common* causes of sterility. They occur in the uterus after puberty, more frequently in certain families, and certainly with great frequency in negroes. The presence or absence of infection seems to have no influence, although some have claimed that adenomyomata may be due to this cause. Nothing is known of the cause of leiomyomata, which occur outside the uterus, and of rhabdomyomata further than what has been given in the discussion of the origin of tumors in general.

Structure.—Leiomyomata are very similar in structure to fibromata (*mutatis mutandis*), and are often difficult to distinguish from the latter. Indeed, they vary, in their relative quantity of plain muscle and fibrous tissue, from the "pure leiomyoma" to the fibroid, which shows no muscle tissue at all. They are clearly delimited from the surrounding tissue and encapsulated, although some of them are rather firmly attached to the surrounding tissue by the formation of excessive fibrous tissue around the blood-vessels which enter the tumor. The softer variety, or pure myoma, is cut more easily than the more fibrous (fibroid tumors), and shows a reddish-gray cut surface, while the more fibrous type conforms to the appearance of fibromata and shows a white cut surface, and produces a grating sensation on being cut. The pure myomata are firmer than normal uterine tissue and the fibroids are much firmer and more difficult of section. Leiomyomata are often nodulated.

Rhabdomyomata show the presence of more or less imperfectly developed striated muscle-fibers, which are found lying among round or spindle-shaped cells. These tumors are sometimes sarcomatous.

Sites of Formation.—Leiomyomata develop in connection with those structures which normally contain smooth muscle-fibers; they are found with greatest frequency in the uterus, and commonly pass under the name of fibroid tumors of the uterus. They are found in the walls of the alimentary tract, from esophagus to the large intestine, and rarely in the urinary bladder. The skin may serve as a point of origin, usually giving rise to very small tumors. Cases have been reported of myomata of the scrotum and the vulva. Rarely they are found in the ovary.

Rhabdomyomata, unlike other benign tumors, do not originate in connection with voluntary muscle tissue; they are always heterologous. They are extremely rare; found most frequently in the kidney, they may also arise from the testicle or the urinary bladder: striated fibers have been observed in tumors of the heart in syphilitic infants, but they probably do not belong to the tumor group. Orlandi has found this tumor originating in connection with nerve tissue.

Diagnosis.—The presence of myomata may be suspected chiefly by the fact that a slow-growing movable encapsulated tumor is found in connection with an organ well supplied with plain muscle-fibers. The softer tumors are more myomatous, the harder ones fibrous. No sharp diagnostic line can be drawn between the two in a clinical way, and none, indeed, is necessary. They vary from the size of a shot to that of a man's head or, rarely, even larger. They may be smooth and round when of moderate size, but as they grow larger they become nodulated, and sometimes present a tangled mass of tumors, some of which are widely attached to the organ from which they arise, or attached to it and to one another by such small pedicles as could not nourish them except for adhesions attaching them to other structures, as the omentum in myomata of the uterus. The attachment of the omentum often bears unmistakable evidence of the source of the chief blood-supply to the tumor in the numerous and enormously enlarged veins and arteries connecting the two. The tumors may be single, but in the uterus are often multiple and sometimes numerous. In the cases of multiple myomata they are seen in all stages of development, a very young one lying alongside, but independent of, a large and old tumor. In the uterus they appear as submucous, mural, or subserous tumors. The mural type may be a diffuse growth, occupying or displacing the whole body of the organ. The submucous tumors are frequent causes of abnormal uterine hemorrhage, of dysmenorrhea, sterility, and abortion, and present grave complications at times when labor occurs at term.

Edematous cystic myomata and those softened by degenerative changes cannot be distinguished in many instances from intra-abdominal cysts. Myomata may grow for years, attain a moderate size not uncomfortable to the patient, and then cease to grow further. The old belief that they disappear at the menopause is untrue and dangerous. Rhabdomyomata cannot be recognized clinically as such.

Variations.—Fibromyoma is the usual form of myoma, pure leiomyoma being rare; the fibrous tissue may predominate, or the muscle tissue, producing hard or soft tumors respectively. Adenomyomata have been demonstrated to occur with considerable frequency, and are due, it is thought (Cullen), to a "flowing" of the epithelial lining of the uterus into its musculature. Myomata rarely show the presence of lymphangiectases or telangiectases.

Pathologic Changes.—One of the frequent accidents befalling myomata in their most frequent site is inflammation of the surface and fixation of the tumor to the surrounding intestines by adhesions, which may become very dense and vascular. Furthermore, inflammation may cause edema of the tumor, suppuration, and thrombosis. Pregnancy and labor favor these conditions.

Fatty degeneration, associated with hyaline degeneration and necrosis of the muscular element, is very frequently seen, and these changes may result in a reduction of the size of the tumor with increased hardness. Calcification occurs usually in old women, but not altogether, and may be found only in isolated spots as a shell surrounding the tumor, or throughout. Of course, calcification precludes the possibility of further growth in the parts affected. Such calcified tumors have been known to be cast off through the vagina or even through the rectum or bladder (uterine stones).

Cystic changes arise from several causes—first, as a result of hemorrhage into the tumor substance; second, from lymphangiectases; third, from myxomatous degeneration of the connective tissue, and, fourth, in adenomyomata from the action of the epithelial cells included in the tumor mass.

Ulceration of submucous tumors and consequent hemorrhage is not an unusual occurrence.

Pedunculated tumors may become edematous and increased in size, or necrotic by torsion of the pedicle.

Myomata do not frequently become sarcomatous, but do so sufficiently often to demand a close supervision over them when for any reason removal is not done. The increased rate of growth or the renewed growth of quiescent myoma should be accepted clinically as positive evidence of malignancy.

Prognosis.—Myomata, by virtue of their frequent origin in the uterus and the broad ligaments, offer especial dangers to the health and life of women which are not usual with benign tumors. They are especially liable to what the late Dr. Richard Douglas called malignancy of position. They are often carried until they reach enormous dimensions without harm, and are finally removed purely because of their disfigurement or burdensomeness. On the other hand, even small tumors may cause most ungrateful disturbances or be beset by dangerous complications. The danger of malignancy, though small, must not escape us.

Treatment.—The general rule for treatment of tumors obtains here as elsewhere. The tumors should, when it is possible, be removed and the organ in which they arise left in position. Hence, in uterine tumors myomectomy should always be given preference (*cœteris paribus*). But the position of the tumors, their number, their size, the distortion they have produced in the body and the canal of the uterus, the complications that have befallen them, and the age of the patient, rendering the retention of the uterus imperative or superfluous, are the factors which must be weighed by the surgeon who wishes to err neither on the side of wasteful conservatism nor on that of unnecessary sacrifice of possibly useful organs.

Rhabdomyomata are to be treated as any other benign tumor, only after having made sure by microscopic examination that they contain no sarcoma cells.

CHAPTER XLII

NEUROMA

A NEUROMA is a tumor which essentially contains new-formed elements of nerve tissue.

The term "neuroma" has been used heretofore in a very broad and, as recent investigations have proved, a very loose sense. In order for a neuroma to be true to the significance of the name it must contain new-formed nerve elements; the simple fact that the tumor has developed in connection with and contains nerve elements that antedate the origin of the tumor no longer being accepted as a justification for classifying them in this group. Thus, many tumors have been removed from the neuroma group and placed in the fibroma group, where they logically belong; von Recklinghausen's disease, molluscum fibrosum, plexiform neuromata, painful subcutaneous tubercle, and the so-called amputation neuromata, while they all doubtless originate in connection with nervous tissue, are eliminated from the neuroma group; "amputation neuromata" are in no sense justifiably classed as tumors, since they are made up of scar-tissue into which regenerating nerve-fibers have grown in consequence of their severance. Since all the pathologic conditions (false neuromata) have been placed where they belong, the term neuroma in its meaning embraces an exceedingly small number of tumors.

Classification.—There is only one single tumor that can, with accuracy, be given as a neuroma—namely, the ganglion-celled neuroma. Another, however, is of such close relation, by virtue of its origin from specialized cells found only in connection with the central nervous system, that it will be discussed here, with the admission that it has long been considered as being a type of sarcoma.

Etiology.—Neuromata are thought to be of developmental origin, as the majority of them have been discovered in very young children.

Structure.—Neuromata are made up of ganglion cells, axones, and dendrites supported by neuroglia. The nerve-fibers found in these tumors are largely non-medullated; a few are medullated.

Sites of Formation.—Neuromata are found in connection with, or in the region of, ganglia and in the skin or subcutaneous tissue. They may develop also in the cerebral ventricles and the ependyma.

Diagnosis.—Neuromata are seen so rarely that one could scarcely have the hardihood to risk a diagnosis. They are slow-growing tumors and cannot be distinguished from fibromata of similar consistence. They usually appear in early life and may be congenital. They are usually of moderate size, although cases have been reported as large as a child's head. The cutaneous tumors may be multiple neuromata and behave throughout, so far as we know, as benign tumors, but should be excised when it is possible to do so.

GLIOMA

This tumor is derived from the neuroglia of the central nervous system. The relation of this tumor to sarcoma has given rise to much learned discussion. However, the origin of neuroglia from the epiblastic layer, and the general behavior of the tumor, has led to the conclusion that they cannot be sarcomatous.

Gliomata are classified into hard glioma (glioma durum) and soft glioma (glioma molle). Occasionally the gliomatous substance is associated with abundant dilated blood-vessels, glioma telangiectaticum.

Structure.—Gliomata are made up of glia cells, their processes and the fibrillar network, as seen in the normal neurogliar structure. The cells are oval or round and mononucleated. The greater the cellular content, the softer the tumor, while abundance of fibrillar elements causes the tumors to be hard. In retinal gliomata the fibrillæ are almost altogether wanting, although the cell processes may be seen. Retinal gliomata are frequently referred to under the name of neuro-epitheliomata, and sometimes as gliosarcomata. The arrangement of the cells surrounding the capillaries is radial; there appear sometimes also rosets of cells due to the radial disposition of cylindric cells.

Sites of Formation.—Gliomata develop only in connection with the central nervous system. Adami claims that they occur only in the brain, in the retina, and rarely in connection with cerebral nerves, and that the excessive glia tissue found in syringomyelia is a gliomatosis. The hard variety is found only in connection with the ventricular walls and projecting into the ventricles.

Diagnosis.—The recognition of gliomata of brain or cord cannot be made clinically. They produce symptoms of pressure, as do other tumors similarly situated. The hard variety are well-defined tumors and can be enucleated satisfactorily, but the soft gliomata infiltrate the surrounding brain substance in such a manner as to render it impossible to recognize where tumor tissue stops and brain tissue begins. They are slow-growing tumors. Hemorrhages occur frequently in the soft tumors, attended with evidence of sudden increased pressure (apoplexy). The retinal form of glioma occurs in the young or may be congenital; they are often bilateral; often one eye will be invaded some months after the other has been enucleated. Several members of the family may be affected, or they may apparently be transmitted from parent to child. Retinal gliomata may grow forward and cause ulceration of the cornea or sclerotic coat and protrude. This form infiltrates the surrounding tissues, and, unlike the central form, produces metastases (retinal gliosarcoma).

Prognosis.—The prognosis of gliomata is unfavorable; the cerebral type, by virtue of its location in an organ where localization and treatment are alike difficult, and where the tendency to hemorrhage may at any moment cause sudden death or permanent crippling; the retinal type, because of the inherent malignancy, with consequent infiltration perhaps along the optic nerve to the cranial cavity, and metastasis. The least harm it can do is to cause the loss of one or both eyes.

Treatment.—The only treatment is removal.

CHAPTER XLIII

SARCOMA

Definition.—Sarcoma is a tumor made up of embryonic mesoblastic cells. It is the malignant type of connective-tissue tumor, exclusive of those derived from endothelial cells (endotheliomata).

Classification.—There are several types of cells found in sarcomata, and they are accordingly classified as small round-celled sarcoma, large round-celled sarcoma, spindle-celled sarcoma, giant-celled sarcoma (myeloma or myelocytoma), or mixed-celled sarcoma, in which there may appear cells of the various types just mentioned.

Fig. 127.—Small round-celled sarcoma. (Microphotograph; × about 100.)

Any of the true sarcomata may be pigmented or free from pigment.

Again, sarcomata are somewhat loosely and incorrectly grouped by their sites of origin; hence, osteosarcoma or chondrosarcoma, indicating only that the malignant tumor has arisen in

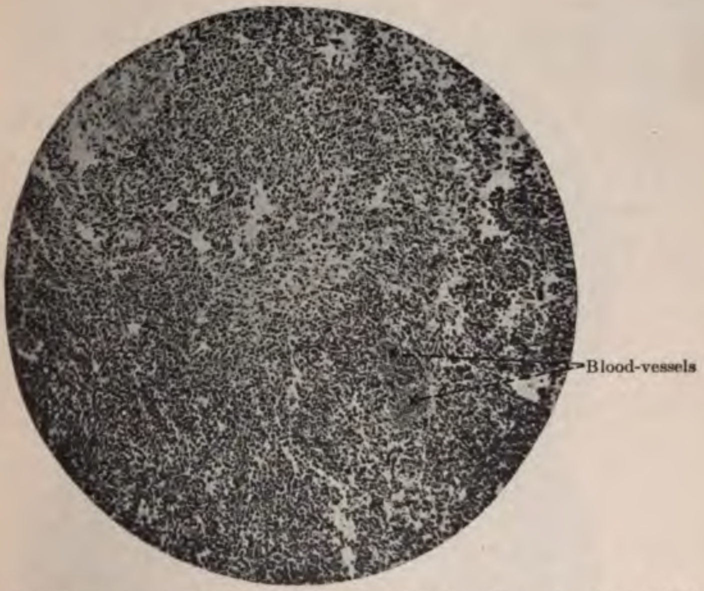


Fig. 128.—Large round-celled sarcoma. (Microphotograph; × about 100.)

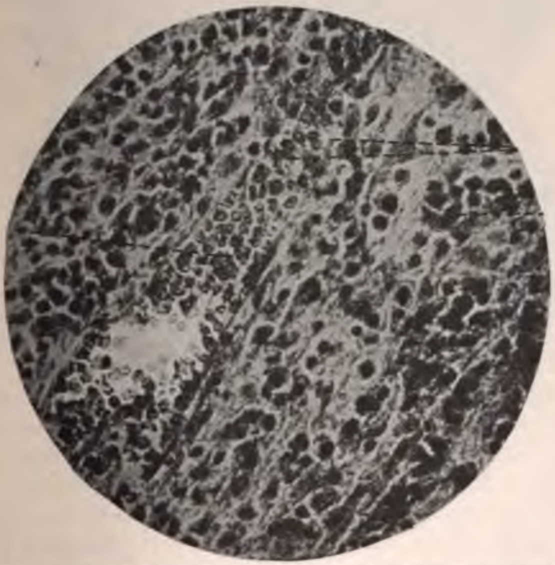


Fig. 129.—Large round-celled sarcoma showing malignant cells in lumen of vessel. (Microphotograph; × about 250.)

connection with bone or cartilage, and not that these histologic structures constitute a part of the tumor structure.

Lymphosarcoma is a type resembling histologically lymphoid tissue.

Besides the above, sarcoma elements are often mixed with other tumor elements which give them a compound name, the chief of which is perhaps angiosarcoma.

Etiology.—Sarcomata arise independently of any known cause and occur at any age; they may be congenital or arise in the very old. The relationship established between the receipt of an injury and the origin of sarcoma is very interesting. A large percen[illegible] of them develop at the site of a recent or remote injury, wit[illegible] no definite time intervening. The degree of injury seems to pla[illegible] no important part in the etiology. Old inflammatory processes, [illegible]oo, may serve as a point of origin, while the sudden assumptio[illegible] of malignant (sarcomatous) symptoms by presumably benign tu[illegible]ors is a matter of rather frequent observation. For instance, I [illegible]ve seen a bite, thought to be produced by a mosquito, result in [illegible] the usual red lump, which failed to disappear and seemed to be slig[illegible]tly inflamed, continue to enlarge, until within a few weeks it wa[illegible] the size of a nickel. Upon excision the microscope showed small ro[illegible]nd-

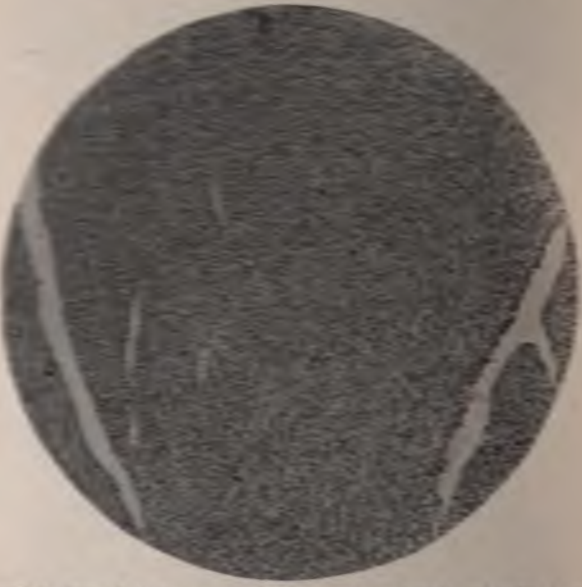


Fig. 130.—Spindle-celled sarcoma of ovary, showing longitudinal and c[illegible] section. (Microphotograph; × about 100.)

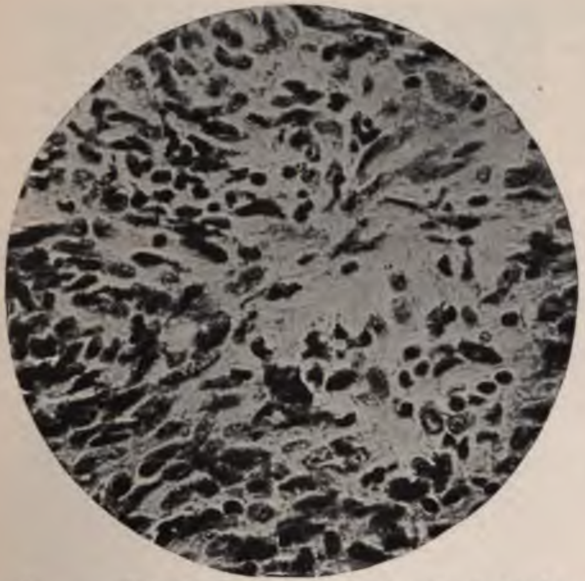


Fig. 131.—Large spindle-celled sarcoma, showing longitudinal and cross-section of cells. (Microphotograph; × about 250.)

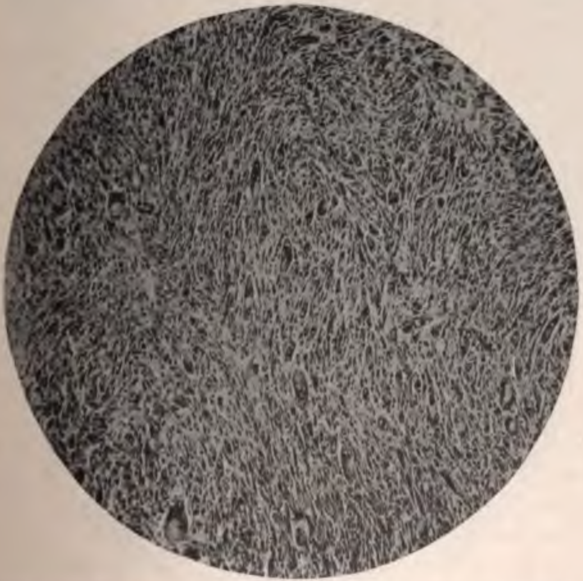


Fig. 132.—Giant- and spindle-celled sarcoma of biceps. (Microphotograph; × about 100.)

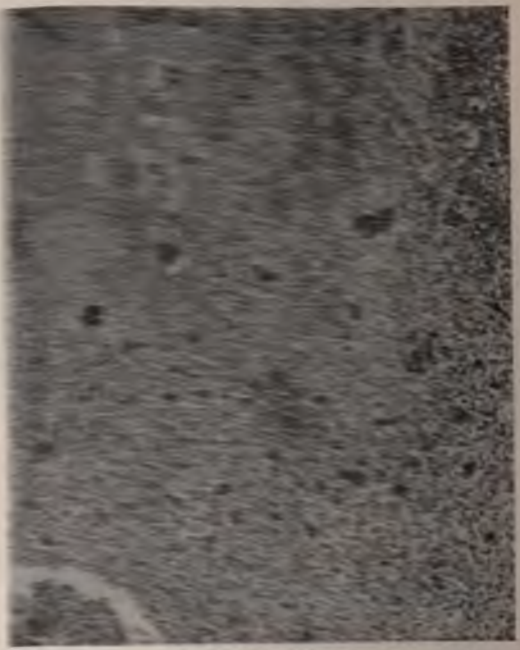
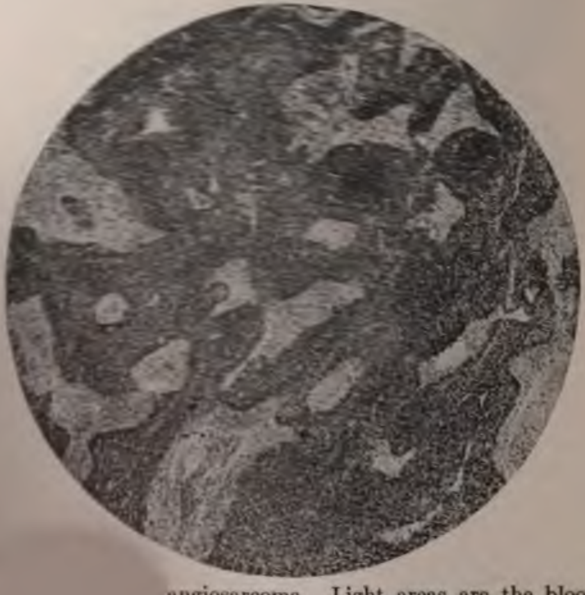
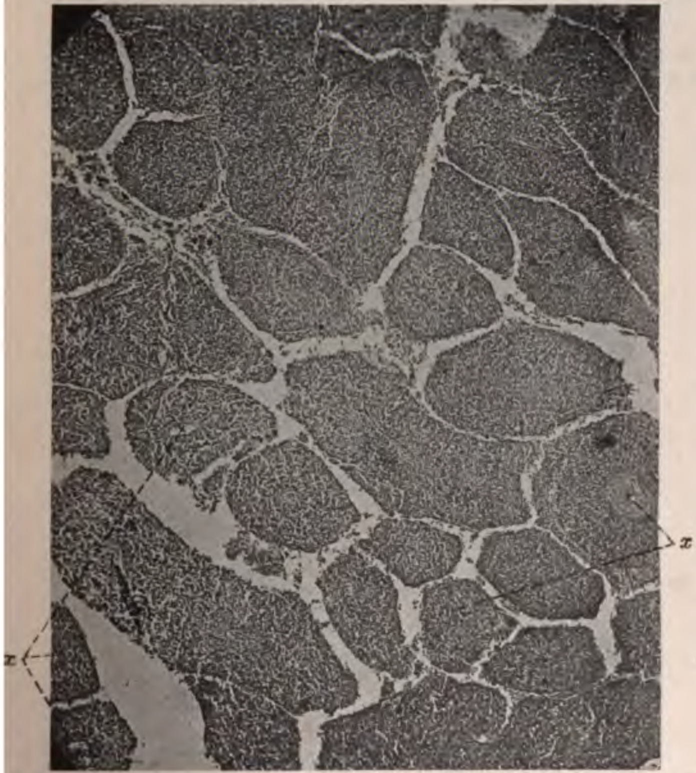


Fig. [illegible].—Medullary sarcoma of tibia, showing giant cells. (Microph
graph; × 75.)



angiosarcoma. Light areas are the blood spac
crophotograph; × about 50.)

lled sarcoma. Another patient had a persistent epididymitis of nococcal origin. During operation for this lesion a small sus-cious-looking nodule was found, which proved to be sarcoma. ıother case had been severely bitten on the calf of the leg by a v twenty years ago. I saw him some months after a tumor had veloped in the midst of the scar. The superficial veins of the were markedly varicosed. The tumor was angiosarcoma.



135.—Telangiectatic sarcoma. Lumen of blood-vessels at *x*. (Microphotograph; × about 50.)

other, a woman of forty, had been spurred in the lobule of her by a sitting hen some five years before; she had a myxosarcoma size of a Malaga grape, about the origin of which she was not ır. Yet, again, a woman of thirty had a pedunculated mole of g standing on her neck, which her physician removed by liga-e of the pedicle. The mole dropped off and the stump healed. six months a tumor had developed at the site of the scar as large an English walnut; her condition twelve months later is shown in Fig. 153. Such cases are so numerous that there can be no doubt that trauma is an important, if only a predisposing, factor in the etiology of sarcoma; it may be further stated that trauma, applied to certain types of tumors, especially moles and fibrous myxomata of the nasal cavity, is to be tabooed, unless the whole growth be destroyed or removed.

Beyond the effect of trauma and the predisposition of certain benign tumors toward malignancy, the real unproved cause of sarcoma remains hidden.

Structure.—Sarcomata are often encapsulated in their early stages with a pseudocapsule; it is conceivable that they may be truly encapsulated at a very early stage, but this cannot be accepted practically under any circumstances, except where old benign tumors are just beginning to show positive microscopic evidence of malignancy. The guide for practice is to be found in the definition of pseudocapsule already given, which may be briefly stated to be a capsule which does not encapsulate, and, therefore, cannot be dealt with as one might deal in positively benign tumors. One can never know if the tumor cells will be found only in the wall of a pseudocapsule or beyond it, and how far beyond.

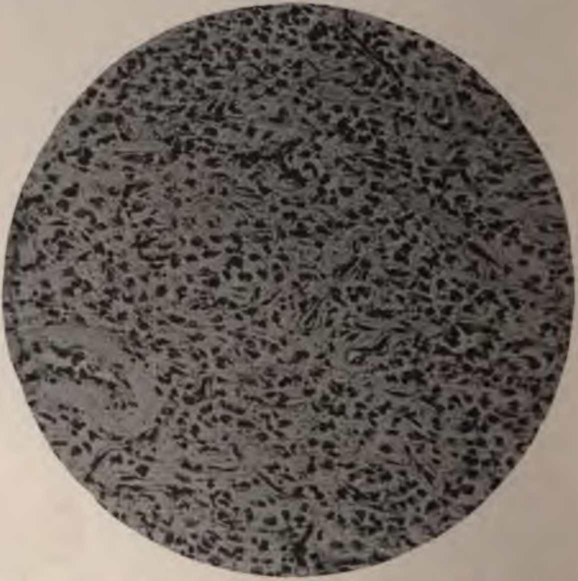


Fig. 136.—Myxosarcoma. (Microphotograph; × about 100.)

On the other hand, sarcoma may show no evidence at en-

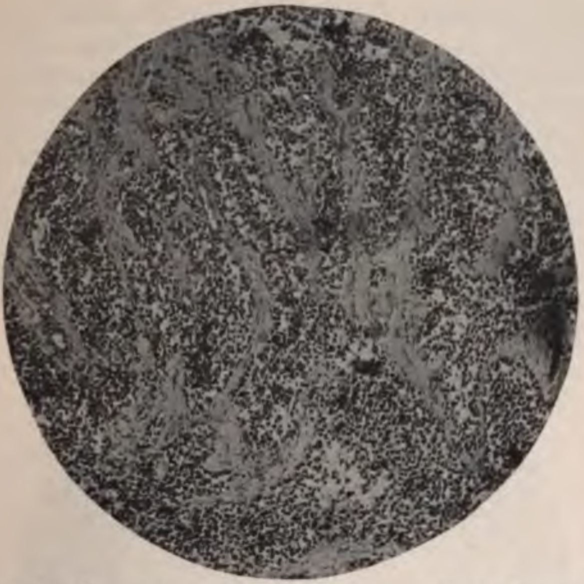


Fig. 137.—Lymphosarcoma. (Microphotograph; × about 100.)

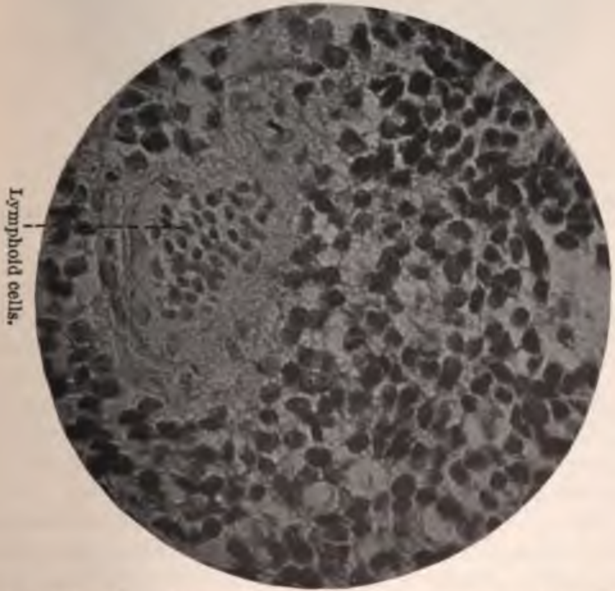


Fig. 138.—Lymphosarcoma. (Microphotograph; × about 250.)

capsulation, and invade the tissues in contact with it in any or every direction. It is of value to note here, however, that sarcomata do not infiltrate habitually as readily or as extensively as carcinomata do.

The structure of sarcoma may be briefly said to be a mass of "embryonic" mesoblastic cells of new formation, held in place by a cement (intercellular) substance supplied with little connective tissue and with numerous blood-vessels, whose walls are so poorly developed as to escape observation very often, thus bringing the cells of the tumor in almost direct, if not direct, contact with the circulating blood.

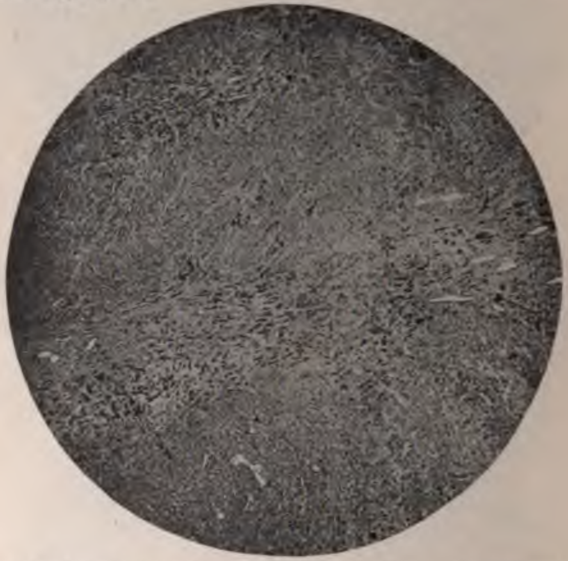


Fig. 139.—Melanoma; × about 15. The black areas represent pigment; this is through entire section.

The bulk of sarcomatous tissue is made up of malignant cells. Portions of tissue which have been invaded may be found incorporated in the tumor mass, usually in an atrophic or degenerative state. The cells show no definite arrangement, and develop about the new capillary loops that form in the growing portion of the tumor. The intercellular cement substance is usually of mucous or fibrillar form, although, when the tumor arises from osseous or cartilaginous analgen, it may be bone or cartilage.

The vessels of sarcomata are poorly developed, being represented by a lining of endothelium resting directly upon the surrounding cellular walls. In other instances they may be supported by a variable supply of connective tissue. The vessels are relatively numerous, and are often more like caverns than ordinary vessels. When they are especially abundant the tumors are called angiosarcomata or, preferably, telangiectatic sarcomata.

The structure of the various types of sarcomata demands discussion somewhat in detail.

Melanotic sarcomata (or melanocarcinomata, as some eminent pathologists call them) are peculiar in respect both of pigment and structure, two facts which have indicated their possible derivation from epiblastic, instead of mesoblastic, cells. Melanosarcomata are discolored by the presence of pigment in their cells. The color varies from brown to black, and may, to the naked eye, appear uniformly distributed throughout the tumor or irregularly distributed, showing on section a uniform or mottled black or brown cut surface. On microscopic examination the cells are of variable shape—spindle, round, and irregular cells all showing. The tumor is seen to be divided into alveoli, through the framework of which the circulation is conveyed. The pigment is distributed in the protoplasm of the cells in the form of minute granules, which are found more abundantly or solely in those cells nearest the alveolar partitions.

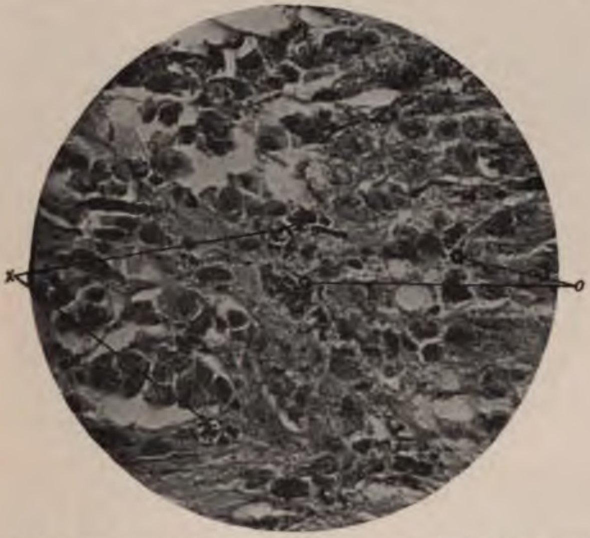


Fig. 140.—Melanoma; × about 250. Melanin granules in the cells at (*x*); in the connective tissue at (*o*).

Lymphosarcomata are so named because of the similarity existing between their structure and that of lymph-nodes or other lymphatic tissue, and because they develop from lymphatic tissue, from which they can sometimes be distinguished only with great difficulty. They are, therefore, characterized by a connective-tissue reticulum, the quantity of which is variable, with a consequent variation in the hardness of the tumor, and of cells held in position by the reticulum. The cells also closely resemble the white blood-corpuscles and the lymphatic corpuscles.

Myxosarcomata are literally a mixed form of sarcoma, in which there is a variable abundance of mucoid tissue. The sarcoma cells are of the polymorphous type, with occasional giant cells, with long processes extending from them. The myxomatous portion may appear as a homogeneous mass or be provided with a small quantity of fibrillar tissue. Sometimes the intercellular substance presents a granular appearance.

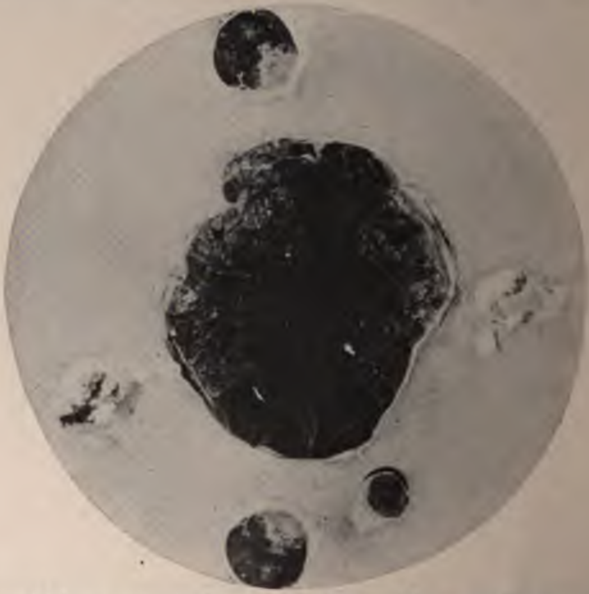


Fig. 141.—Melanosarcoma of popliteal space. Note small metastases surrounding primary large growth. (Almost natural size.)

It will be seen from the above that the commonly employed nomenclature of sarcomata is somewhat at variance with the usage in other tumors. For example, adenomyoma means a tumor made up of glandular and muscular tissue. On the contrary, osteosarcoma signifies sarcoma arising from bone, whether the tumor itself contains bony elements or not; chondrosarcoma similarly means sarcoma arising from cartilage. Lymphosarcoma is one containing lymphoid elements; angiosarcoma is usually employed to represent sarcoma telangiectodes. Myxosarcoma possibly represents a true mixture of tumor elements.

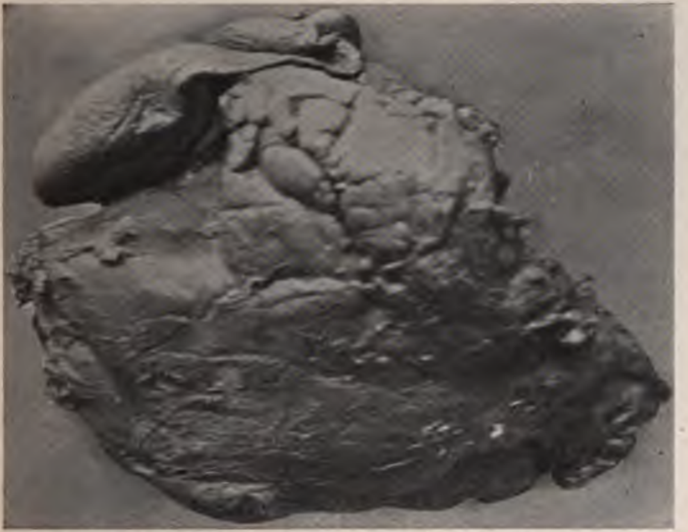


Fig. 142.—Enormous mediastinal lymphosarcoma.

The consistence and the cut-surface appearance of sarcomata is of great importance from a pathologic standpoint. Like other tumors, it will be understood that the greater the cellular content and the less stroma, the softer the tumor will be, provided the tumor is not a myxosarcoma; here, of course, the greater the proportion of myxomatous tissue, the softer the tumor will be. The supposition that an osteosarcoma and chondrosarcoma contain bone and cartilage respectively has led to an unfounded belief that

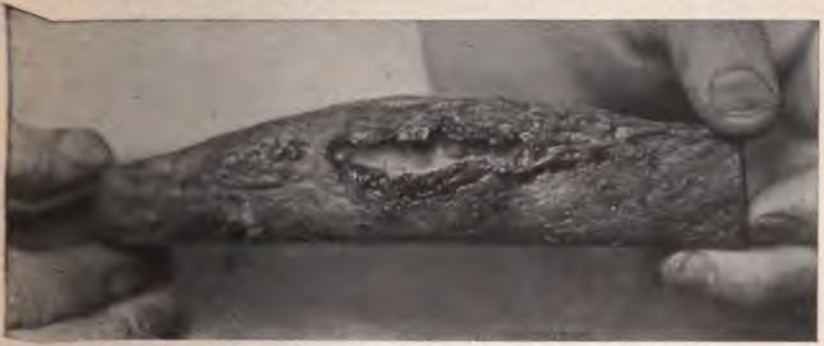


Fig. 143.—Myxosarcoma of tibia, showing resected portion of bone.

such tumors are necessarily hard tumors, whereas the very name sarcoma signifies a fleshy, and, therefore, a more or less soft tumor; and if these classes are occasionally hard it is not to be concluded that they are universally so. Sarcomata are often so soft as to be distinctly fluctuant; this is especially so if hemorrhage has escaped into the tumor substance or if cysts have developed within it.

The cut surface of sarcoma is often so characteristic as to render microscopic examination almost superfluous. The color is gray or grayish red, or distinctly red if there has been abundant hemorrhage into the tumor substance. The surface usually has a suggestion of translucency. Punctate hemorrhagic spots may often be seen distributed over the surface, and often large quantities of blood may be encountered. This is especially true of the softer, rapidly growing tumors. Sarcomata are usually cut with ease, and many are so fragile as to be torn to pieces as easily as necrotic tissue. The consistency of myxosarcoma and of old degenerating portions of other sarcomata is that of soft gelatin.

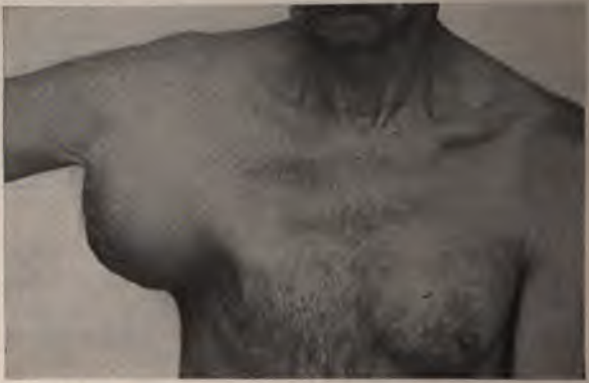


Fig. 144.—Sarcoma of axilla of ten months' duration. Inoperable.

Sites of Formation.—Since sarcomata are mesoblastic tumors, it follows that they can develop only from those tissues derived from this embryonic layer. There are, however, as a matter of fact, only a few of the mesoblastic histologic tissues which afford origin to malignant tumors. They all belong to the connective-tissue framework, with the exception of the lymphatic tissues. By far the majority of sarcomata arise from the connective-tissue proper, whether it be from cellular tissue, aponeuroses, tendons and tendon sheaths, or skin. Next come those which originate in bone or periosteum (myeloid and periosteal sarcomata), and last those derived from lymphatic tissue. This statement holds true, whether malignant gliomata are admitted into the class with sarcomata or not, inasmuch as the glia serves as a connective tissue to the central nervous system.

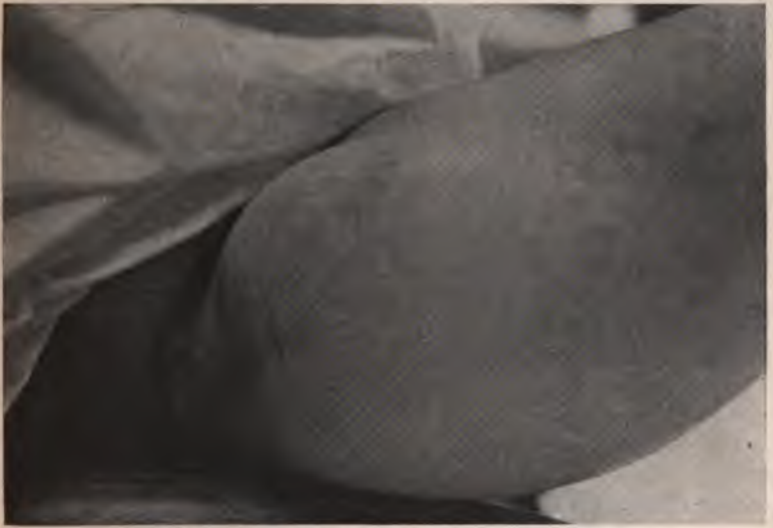


Fig. 145.—Recurrent cystic sarcoma of the thigh.

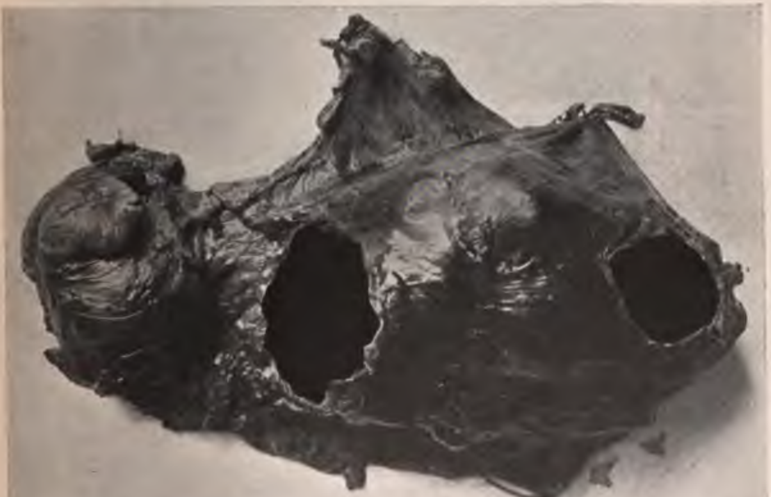


Fig. 146.—The same tumor after removal, showing cavity of cyst.

Furthermore, when benign tumors become sarcomatous, it is by virtue of changes in the cells of their connective-tissue content and not in the more highly specialized cells. An exception to the broad statement must be made relative to malignant (sarcomatous?) hypernephromata, which originate from misplaced rests of adrenal tissue.

Sarcomata of the Skin.—Sarcomata appear as congenital tumors of the skin, as independent tumors acquired at any age with or without a history of trauma, and as secondary changes in the most common benign tumors affecting this membrane, namely, moles, whether pigmented or not, and occasionally from vascular nevi, especially the pigmented variety. The skin affords the greatest number of pigmented sarcomata; and they are especially likely to arise from moles or flat pigmented nevi, although pigmented sarcomata do not all have such antecedents. The majority of skin sarcomata are secondary to moles, and are more likely to develop if the mole has been injured, irritated, or imperfectly removed. Sarcomata of the skin arise from the cutis or subcutis, and while they are usually spindle celled and firm, the larger and longer the cells, the firmer; however, large or small round-celled sarcomata are seen, and are softer than the spindle-celled tumors. The large round-celled tumors sometimes present a distinct alveolar arrangement.

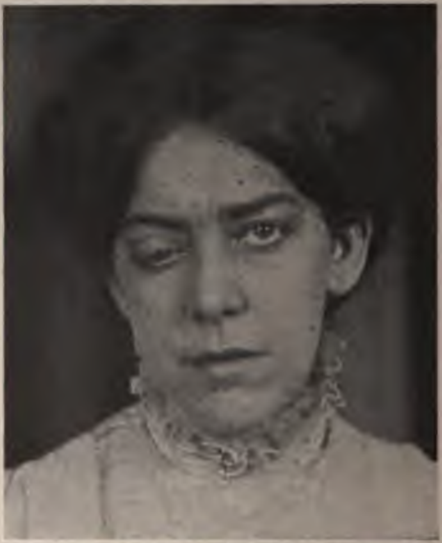


Fig. 147.—Sarcoma of base of skull protruding into orbit.

In skin sarcomata mixed forms are sometimes observed; fibrosarcoma, in which fibrous tissue is abundant, although it is not unusual for a moderate quantity of fibrous tissue to be present;

myxosarcoma, of which the majority occur in very young children; and angiosarcoma, which appears as a firm or soft tumor, dependent upon the relative quantity of sarcomatous and vascular tissue. Vascular (angio-) sarcomata may develop rarely from angiomata, but, as a rule, they grow slowly and fail to give one the impression of malignancy unless they are pigmented. Another tumor of the skin should be recalled here, namely, lymphendothelioma, which arises from the endothelial cells of the lymph-vessels, but cannot be distinguished clinically from sarcoma. Kaposi has called attention to a condition which he designates idiopathic multiple pigmented sarcoma of the skin. It is at present not thought to be sarcomatous, as it may persist many years and disappear without treatment; sometimes the nodules do unquestionably become malignant.

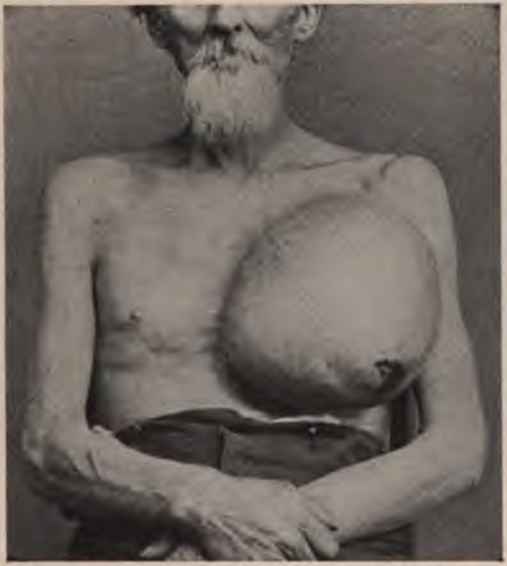


Fig. 148.—Sarcoma of breast in an old man.

Sarcomata of the skin appear as roundish, smooth tumors with variable tendency to lobulation, and are usually sessile, though they may be pedunculated.

Secondary sarcomata of the skin may be seen in any metastasing sarcoma, but are especially likely to follow osteosarcoma or intestinal sarcoma

Connective Tissue and Fascia.—It is readily understood that sarcomata, which are connective-tissue tumors, should originate from connective tissue in the majority of cases; and with the exception of lymphosarcomata we may accept as true the statement that all sarcomata do arise from connective tissue, and that when a sarcoma originates in an organ whose chief structure is parenchyma we may be sure the malignant growth found its origin not in the functionating specialized cells, but in the supportive stroma. The discussion of sarcoma of connective tissue and fascia is not intended, therefore, to leave the impression that this type of malignant tumor arises from other sources. In the subcutaneous, submucous, and intermuscular connective tissue, in the aponeuroses and the adipose layers, in tendons and bursæ, in the periosteum (which will be discussed with sarcoma of bone and periosteum) sarcomata find their origin very frequently, and rarely from vascular sheaths and the retroperitoneal connective tissue.

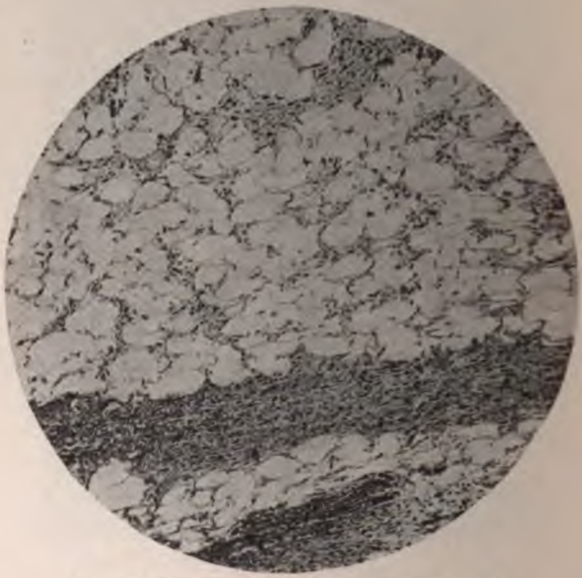


Fig. 149.—Myxo-lipo-sarcoma; × about 100.

Sarcoma of the intermuscular fascia and aponeuroses develops with far greater frequency between the large muscles; the sites most commonly affected being the hip and upper thigh, the shoulder, arm and neck, the abdomen, and the leg.

Bone and Periosteum.—The term "osteosarcoma" has very unfortunately crept into the literature of tumors, and is used to signify a sarcoma which originates from bone regardless of the structure of the tumor. It is better, I believe, to dispense with the term here to avoid confusion, under the two headings of myelogenous sarcoma of the bone and periosteal sarcoma of the bone, for while it may be more pertinent from a histologic standpoint to discuss periosteal sarcoma in conjunction with those arising from the fibrous connective-tissue fascia, there can be no question as to the practical value of the adopted arrangement.

Myelogenous sarcoma of bone may be found appearing in connection with any bone of the body; it appears by preference in certain very definite bones, of which the jaws, more especially the lower jaw, head the list; it appears with great frequency also in the epiphyses of the long bones, rarely in the diaphysis. The long bones most frequently affected are the tibia, and then the radius and the ulna. Myelogenous tumors are of various structures, small or large round celled, spindle celled, or mixed. They often show great numbers of giant cells. The cells may assume an aveolar arrangement, like carcinoma.

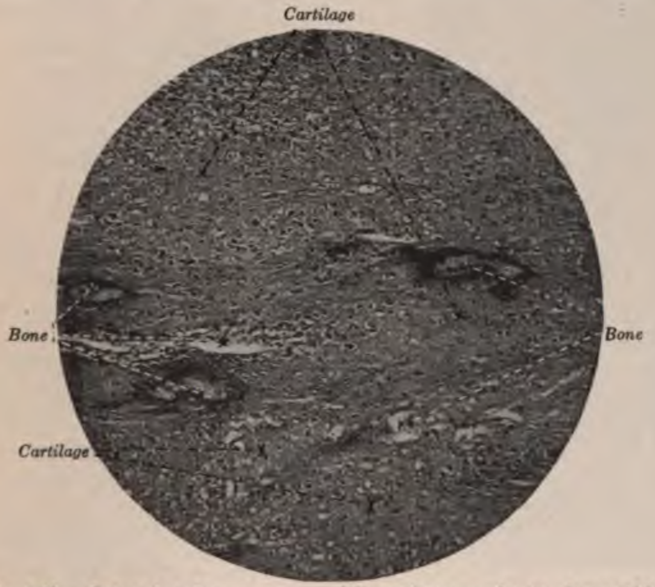


Fig. 150.—Osteochondrosarcoma. (Microphotograph; × about 100.)

The periosteal sarcomata of bone originate chiefly in the ends of the long bones, but may occasionally be seen on any part of the skeleton. They are round-, spindle-, and mixed-celled tumors with giant cells showing occasionally.

Lymphatics.—Round-celled, spindle-celled, and pigmented or angiosarcomata are rarely observed as primary sarcomata of the lymph-nodes, and when they do arise from them they are in appearance the same as usual, and identical in origin, arising, namely, from the connective tissue.

There is, however, a peculiar form of sarcoma whose connection with the lymphatic structures of the body is very intimate and whose behavior is peculiar, viz., lymphosarcoma. The name is applicable because the structure of the tumor microscopically resembles that of lymph-nodes so closely that frequently it is necessary to invoke the clinical history to settle their true nature, unless the section examined be obtained from an infiltrating border; the name applies as well because of the fact that these tumors are thought to arise from lymphoid tissue, wherever it may be found.

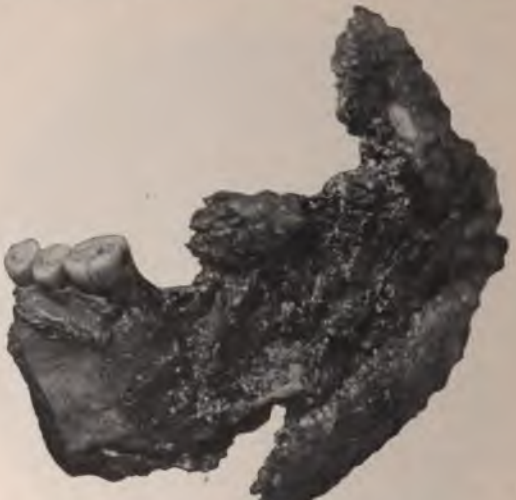


Fig. 151.—Lower jaw resected for sarcoma, showing tumor and pathologic fracture.

There are two types of lymphosarcoma—localized and general. The former is far the more common and occurs with greatest frequency in the neck, the mediastinum, the mesentery, and the retroperitoneal lymph-nodes, in all of which except those from the thymus they produce multiple and enormous enlargement of the nodes. The lymphoid tissue of the throat and the gastric and intestinal mucosa also serve as starting-points.

The diffuse or general type is far less common. It may arise from any lymphoid tissue and produce a general metastasis, in contrast with the localized growth of multiple tumors in the regional type.

Nervous System.—The central nervous system, more especially the brain, may be occasionally the starting-point of primary sarcomata, that is, they may originate from the stroma of these structures; they are much more frequently affected by sarcomata which have developed from their meninges, the bony walls surrounding them, or the periosteum covering this bone. The tumors are usually either spindle or mixed celled.

The nerves are occasionally the source of sarcomata, and the types usually found are spindle-celled and myxosarcomata. Sarcomata of the nerves are produced in consequence of malignant change of pre-existing benign tumors, one-twelfth of all cases of multiple fibromata dying ultimately of sarcoma (Bruns).

Alimentary Tract.—Sarcomata of the esophagus and stomach are seldom seen. They may in either situation arise as primary tumors or in consequence of malignant changes in benign tumors. In the stomach they usually arise from the submucosa or the muscular layer (or subserosa), and rarely from the mucous membrane.

The intestine is likewise rarely affected by primary sarcoma, and the cecum and lower ileum are the parts most frequently attacked. The tumors are round- or spindle-celled and may be alveolar.

The rectum rarely is affected by sarcoma, but it may be; and rectal sarcomata are sometimes melanotic. Sarcomata of the intestines occur much more frequently (three times) in males than in females. Lymphosarcoma shows a predilection for the intestines and may be primarily multiple.

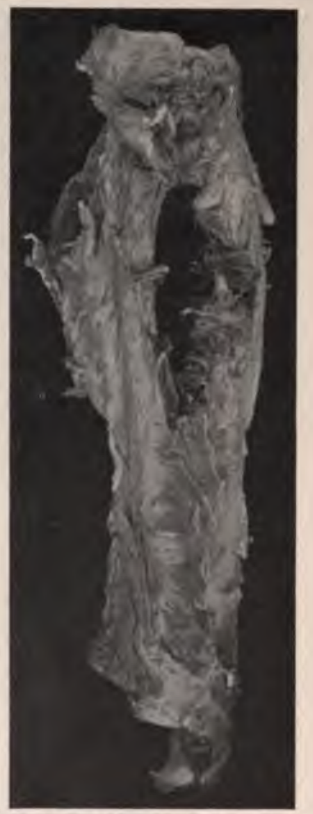


Fig. 152.—Spindle-celled sarcoma affecting the radius and the ulna.

Liver.—This organ rarely serves as the site of origin of primary sarcoma, being much more frequently affected by secondary tumors. However, reports of many types of sarcoma—round-, spindle-, giant-celled, and angiosarcoma—have been made.

The pancreas and spleen are rarely affected by primary sarcomata.

Ovaries.—Sarcoma of the ovaries occurs with moderate frequency, and is often found attacking both ovaries at the same time. The tumors are spindle-celled usually; however, mixe celled, round-celled, giant-celled, and myxosarcomata are son times found. In addition, there occur tumors which appear to

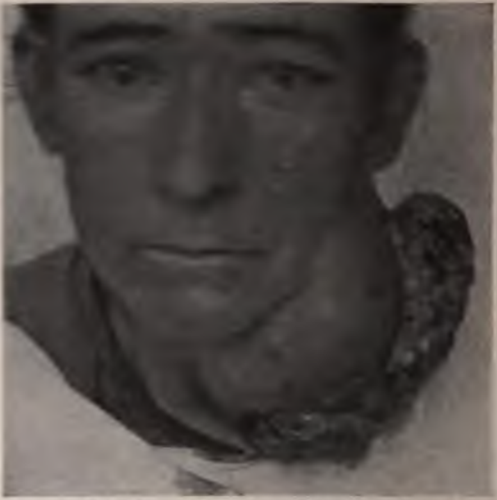


Fig. 153.—Sarcoma of neck resulting from ligation of a pedunculated mol

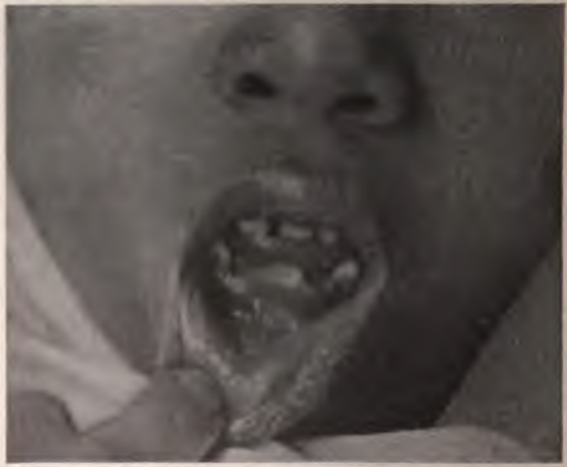


Fig. 154.—Sarcoma of lower jaw in a child whose permanent incisors are j beginning to erupt.

mixed, such as perithelioma mixed with endothelioma, sarc and carcinoma, or sarcoma with adenoma or cystadenoma. few melanosarcomata of the ovary have been reported.

Uterus.—Sarcoma of the uterus may develop as a primary tumor or as a malignant transformation of fibromyomata. In the corpus they originate from connective tissue or the blood-vessels of the endometrium, or from the myometrium. Cervical sarcomata, though less frequent than those in the body, may appear in bunches or in the form of polypi. Sarcomata of the uterus are usually round- or spindle-celled or the two mixed. Giant cells are sometimes found. The cervical variety are frequently lymphangiectatic spindle-celled tumors, and they may be myxomatous or edematous. Sarcoma and carinoma are rarely found growing synchronously in the same uterus, or they may appear as mixed tumors, sarcocarcinoma, in which it is stated that the stroma of a cracinoma has undergone sarcomatous change.

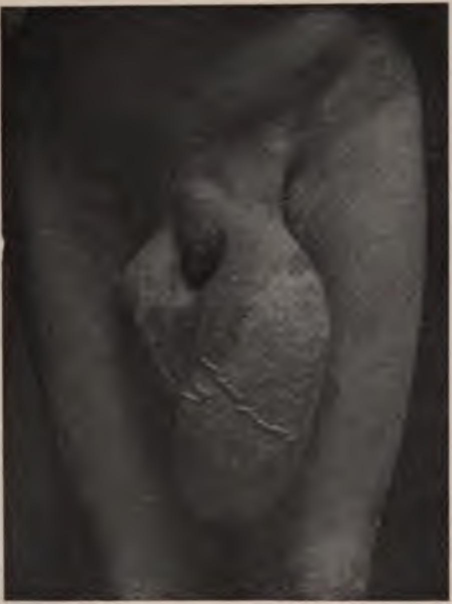


Fig. 155.—Sarcoma of testicle.

Testicles.—As in the ovaries, so here the tumor may originate either as a unilateral or bilateral affliction; they may appear very early in life, and in any age usually arise from the testicle proper. The extension of the tumor by infiltration through the testicular coverings results in a fungoid ulcer known as fungus sarcomatodes. The same confusion of cell types is found here as in the ovaries, although the round- and spindle-celled varieties predominate. Pigmented sarcoma is rare. Adenosarcoma and sarcocarcinoma are very rarely observed. Sarcomata of the testicles very often contain glycogen.

Diagnosis of Sarcoma in General.—Under this caption it is necessary to call attention to the fact that many of the notions held by some of the profession are due to ancient teachings that have been handed down from generation to generation, without an attempt to correct them in accordance with the advances made by pathologic study and clinical observation of patients before and after treatment, and by our ability to make accurate diagnosis microscopically long before a clinical diagnosis could be vouchsafed. Hence, much that is untrue is still accepted and occasionally acted upon as true.

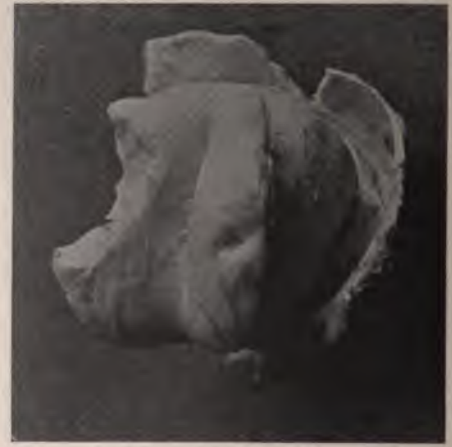


Fig. 156.—Sarcoma removed from labium majus, showing capsule dissected back.

Before discussing the subject in detail it is perhaps wise to give a condensed statement of the diagnostic features of sarcoma. Sarcoma arises from mesoblastic structures, and may, therefore, appear either as a very superficial or deep tumor. In a considerable percentage of cases there is a history of trauma or of a benign tumor. Sarcoma is usually a rapidly growing tumor, and the assumption of a malignant change on the part of benign tumors is to be suspected when they begin to grow rapidly after a prolonged period of slow increase in size or of quiescence. They grow as more or less spheric tumors when small, but are often nodular or lobulated when large, and are caused to deviate from the spheric shape by the influence of their environment. They are usually firm, flesh-like tumors, or may be so soft and fluctuant as to lead to the diagnosis of abscess; on the other hand, they may be extremely hard. Sarcomata are often pseudo-encapsulated and are thus as movable as if they were benign; as a rule they are less likely to become fixed by infiltration and to mat various layers of tissue together than carcinomata. Lymph-node involvement does not occur except in rare instances, as in the tonsil and the testicle. The age of sarcoma patients varies from the unborn fetus to the octogenarian, and it is probable that the majority occur in the most active years of life, between the ages of fifteen and fifty years. The idea that sarcoma is found most frequently in the young has long been disproved. Pain, as a rule, is absent, and comes only after the tumor has reached a rather advanced development, when by its size or location it causes pain, frequently just as a benign tumor similarly situated would. The presence of pain has some diagnostic value, its absence in tumors means nothing. Fever is occasionally present, especially in advanced sarcoma of the viscera, and may lead to the suspicion of malaria or a low-grade infection. The general effect of the tumor is to produce cachexia, but it is not an unusual thing to find even large sarcomata with little or no evidence of cachexia, provided no complications—especially ulceration, infection, or hemorrhage—have occurred.

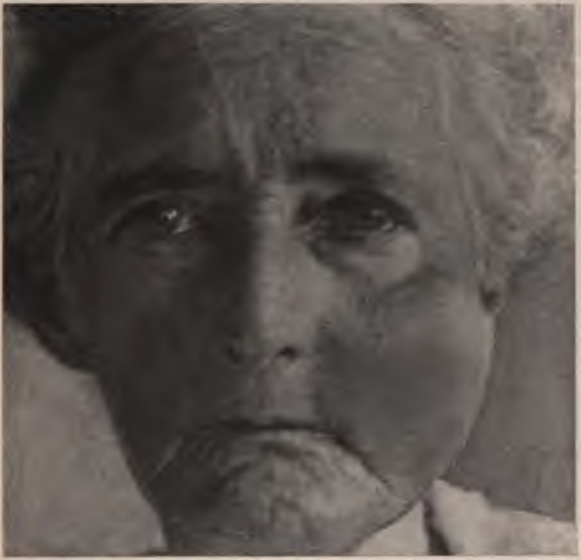


Fig. 157.—Sarcoma of superior maxilla.

History.—The question of hereditary influence in the production of sarcoma is of no demonstrable importance and may be discarded. However, it is of extreme importance to know that the tumor has arisen at the site of a previous injury, and the tumor may begin to develop immediately and grow with astonishing rapidity, or its appearance may be delayed for an indefinite time. The nature of the injury or its degree seems to have little to do with the case. Sarcomata arise from great or small injuries, and if there is any difference, it is in favor of minor injuries. The fact that a tumor has been present for a number of years is most important, although its clinical course has led to a conclusion that it was benign. When an accelerated rate of growth takes place in such a tumor it is of the highest evidence that it has become malignant; the evidence is intensified if the "benign" tumor was of a type prone to become sarcomatous, especially moles, myxomata, and fibromata, and if it has previously been injured or incompletely removed.

Age.—It is of no importance to consider the age of a patient in cases of sarcoma, except in so far as the age may render it necessary to differentiate between this and other tumors, especially carcinomata, for sarcoma is, above all, a tumor affecting all ages. It may be congenital or occur at any time thereafter. Rodman found the average age for spindle-celled sarcoma of the breast to be 36¾ years, and of round-celled sarcoma, 47½ years. I have personally seen many more cases of sarcoma, generally, occurring in the middle aged than in the young.

Mode and Rate of Growth.—By close observation of an actively growing sarcoma for a period of a few weeks a very important idea of its nature may be gathered. The question as to what constitutes a rapidly growing tumor and what a slowly growing tumor cannot be dogmatically stated. Besides, there are benign tumors which grow relatively fast, and malignant tumors growing relatively slow. The best rule to follow is to consider all tumors growing suspiciously as malignant, unless they can be, or until they shall have been, demonstrated to be benign.

I have stated already that sarcomata tend to grow in the shape of a sphere, yet when they are surrounded by large muscles or bone they are more or less flattened or distorted by pressure. Sarcomata are sometimes pedunculated, *e. g.*, those arising from the cervical canal.

The growth is most rapid along the lines of least resistance. Hence, when the tumor is situated primarily in a bony cavity, processes of tumor tissue may protrude through apertures and cause apparent secondary growths in an adjacent cavity or on the outer surface of the bone. The process leading from the first to the second nodule may be so attenuated as to escape observation, and such outgrowths are often the cause of return of the tumor in the same region. The tendency for sarcomata to occur in the form of a large primary tumor more or less surrounded by smaller nodules is very important, and is probably due to extension in the manner just described.

Size.—The ultimate size obtained by sarcomata is limited, it would seem, only by the death of the patient. It is not unusual to find tumors as large as a child's head and sometimes as large as an adult's head. I have removed a spindle-celled sarcoma of the uterus which weighed 13 pounds. The largest tumors are probably those arising from the kidneys and the retroperitoneal space.

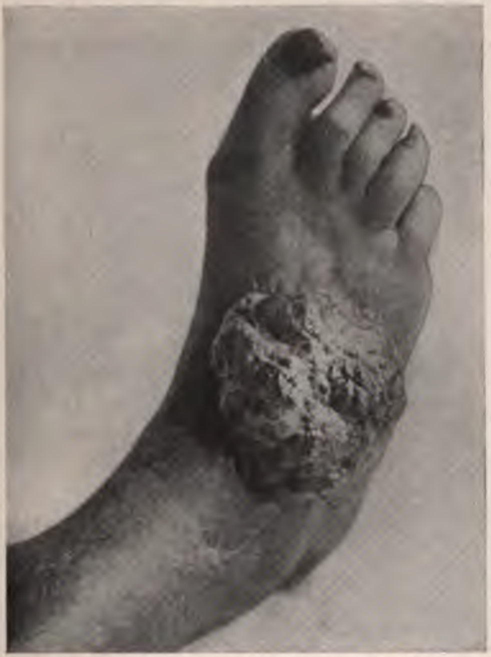


Fig. 158.—Pigmented sarcoma of the foot.

Surface Appearance.—In superficial sarcomata, especially those of the skin and all those which have grown close to it by infiltration from deeper structures, the surface may or may not appear red, as if an inflammatory process were present. This, of course, depends on the extent of skin involvement and the circulation present. The skin usually appears normal until infiltration has taken place, and is altered only in consequence of the stretching produced. In superficial or deep sarcomata the subcutaneous veins overlying the tumor are often enlarged as compared with those of the opposite side. The tumor may pulsate or give rise to a purring sound, a kind of bruit, from the excess of circulation.

It is important to state in this connection that a very valuable evidence of malignancy can be discovered at times by examining the surrounding tissues for evidence of an increased arterial flow, which adjusts itself in case, for example, of uterine sarcoma just as in cases of pregnancy. So, too, in malignant tumors of the bladder enlarged arteries may often be palpated *per vaginam.*

Myxosarcomata of the skin may be translucent, and pigmented sarcomata naturally brown, black, or mottled.

Consistency.—This factor may be said to vary throughout the range of possibilities. A sarcoma is usually a moderately firm tumor of flesh-like consistency, firmer than relaxed muscle or than a lipoma. In certain instances, namely, the myxosarcomata and the hyperacute sarcomata, they may be as soft as a cold abscess, and are, indeed, mistaken for collections of fluid. When the sarcoma is cystic or when recent abundant hemorrhage into the tumor mass has occurred the tumor becomes distinctly fluctuant, and it is different from a cyst in feel only by the thickness of its walls, which may be variable, if palpable. On the other hand, the tumor may appear as firm as a fibroid, and from its physical appearance be indistinguishable from it. It may be even

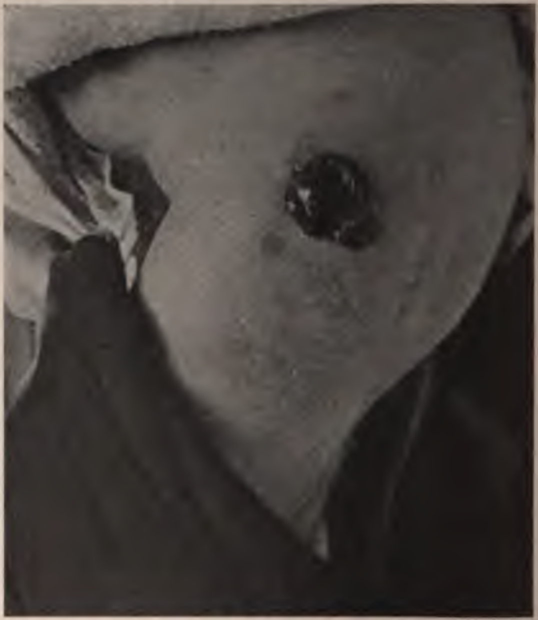


Fig. 159.—Pigmented sarcoma of thigh, which grew from size of a grain of corn in two months following an injury. Observe enlarged inguinal node.

harder and give evidence of being osseous or cartilaginous, although it must not be concluded that all osteo- and chondrosarcomata are of this consistency.

From the above statements it becomes clear that there are no uniform standards for the consistency, such as are found in lipoma, for instance, and that while it may resemble any tumor in this respect, other factors must be employed to determine its true nature.

Encapsulation and Mobility.—The capsule of some sarcomata is so perfect that they may be easily enucleated from their bed (Fig. 156). Others show no effort at encapsulation and behave malignantly from the outset. All lose their encapsulation at some time by infiltration through its walls, and usually ultimately destroy all vestiges of it. So long as the tumor is encapsulated, if it is at all, it deports itself as an encapsulated benign tumor. Malignancy and benignity have nothing to do with the mobility of a tumor in its early development, but this is determined by the presence of a capsule, which separates it in a gross way from the surrounding tissues. This is exceedingly important, for the frequent encapsulation and free mobility of sarcomata in their earlier stages cause the unwary to render a hasty diagnosis of innocency, and to allow the golden time of safety to escape. There are certain tumors which grow slowly for a time, are unquestionably encapsulated and movable, which when they escape their capsule assume the rôle of violent malignancy, so that the question has been raised whether they were benign tumors from the beginning, or only malignant tumors behaving benignly for the time. From a practical standpoint it would be better to consider that the tumor was malignant from the beginning, unless all were fully aware that practically every tumor should be considered a menace to the life of its host, whether at present it is malignant or not.

Infiltration and Immobility.—While sarcoma is, as a rule, more frequently movable and longer movable than carcinoma, it must be impressed that all sarcomata do infiltrate the surrounding tissues, in many cases even from the beginning. The growth of the tumor into surrounding tissues causes degeneration, disintegration, and loss of function, and the presence of the tumor-cells in a muscle, for instance, may be recognized among the muscle-fibers by the microscope or even by the naked eye. Certain structures are less liable to infiltration, chief of which may be named lymph-nodes, which may be found sometimes completely ensheathed in the sarcoma mass, but showing no invasion of their substance, cartilage, and synovial membranes, the exception of which constitutes remarkable pathologic phenomena; these two last statements are illustrated by the infrequency with which sarcomata of bone invade the epiphyseal cartilages, and the rare invasion of a joint cavity by a sarcoma lying close to it. Blood-vessels form no exception in the infiltration processes; the walls of veins are infiltrated, and on reaching the lumen the cells rapidly multiply until a mass occludes the vein and often grows for a considerable distance and serves as a plug which prevents hemorrhage in case the vein is cut, but offers an unquestionable guarantee of recurrence. From the infiltrating masses in the veins plugs may be broken off by accident or in the natural course of events, and produce embolism with its symptoms, or metastases by lodging in vessels which are not sufficiently concerned in vital processes to produce symptoms. The growth of processes along the various channels of the body is so closely allied to infiltration proper that further elaboration is deemed unnecessary. The growth of sarcomata along the coarser channels has already been referred to. The same thing occurs in sarcoma of the bone or periosteum; once it passes the limits of its capsule it may send processes along the Haversian canals or the channels conducting the blood-vessels until the periosteum or marrow is respectively invaded. So, too, in sarcoma of the eye, the growth may invade the veins and extend along them until it reaches the surface of the sclerotic, where it produces small nodules in the venæ vorticosæ.

Mediastinal lymphosarcomata will gradually surround nerves, bronchi, vessels, and pericardium, enter the lung at the root, following the structures entering there, and compress and collapse them until their function is destroyed. It may grow upward under fascial planes, underneath the cervical muscles, and expand on reaching the triangles of the neck, not as metastases, but as one tumor mass. Likewise, in sarcomata occurring about the spinal column, paraplegia may result from a direct growth of the tumor through the intervertebral foramina and intraspinal enlargement occur, which produces pressure on the cord. There is no nook or cranny through which these tumors, hideous alike to the surgeon and the patient, will not enter so easily, so quickly, and with so little trace that the surgeon must not only overlook such extension, but may be compelled, even though suspecting it, to refrain from an attempt at removal.

From the preceding discussion of infiltration it is clear that no structure of the body is immune to invasion of its substance by sarcoma, and while the tumor may be movable at the beginning, there comes an indefinite time, the more malignant the tumor, the earlier, from which immobility is established; and that as the infiltration continues it may bring anatomic structures normally movable in relation to each other into an inseparable and often indistinguishable mass.

Metastases.—There can be no doubt that tumor-cells, both benign and malignant, gain access to the blood-stream, and possibly to the lymphatics occasionally, benign cells more rarely but without doubt, as indeed may happen with normal tissue-cells, and malignant cells very frequently. The growth of such cells into tumor masses, essentially of the same nature as the structure from which they originated, depends on the power of the cells to take hold at a new point and to multiply into a tumor mass, on the resistance shown by the tissues at the site of lodgment and the influence trauma and disease may have on this resistance. Hence, we are in position to understand how it happens that with marked uniformity certain organs escape metastases, and others with as great uniformity are affected by them, and how malignant tumors of certain structures show a predilection to metastasize in certain anatomic structures, as, for example, the preference of melanotic metastases for the liver, facts which cannot be explained on a theory of chance distribution, and which are supported by our knowledge of the distribution of metastatic abscesses in pyemia.

The histologic structure and the method of cell multiplication in sarcomata show the ease with which the cells of a sarcoma might get into the circulating blood; the blood-vessels are abundant, relatively large, with no vessel wall save a single layer of intima cells separating them from the tumor-cells, and in many instances even no intima is present, the blood coursing through channels whose walls are made up of tumor-cells. The absence of connective tissue in sarcomata and the greatest multiplication of cells around the blood-vessels favors the same course. In addition to this, the infiltration of normal vessels by sarcoma cells and their growth along the lumen may similarly serve as the source of metastases. With the above facts clearly before the reader, he cannot fail to appreciate the evil influence trauma may play upon a sarcoma by liberating cells from the tumor into the circulation; how massage or unnecessary manipulation are not only superfluous, but hazardous; how it becomes a dangerous practice to cut into the tumor mass for a microscopic section, especially unless it is done for immediate use and the wound is allowed to remain open meantime; how in operation for these tumors Esmarch's bloodless method is contra-indicated; how gentle handling of the tumor is required, and why the tumor mass should never be lacerated or incised; for if by any of these procedures sarcoma cells are liberated and gain the general circulation they render hopeless a case that might otherwise be curable. There is no definite time prior to which it can be said that metastasis has occurred, and if we remember that it requires some time for the metastasizing cells to gain a footing and produce a discoverable tumor, and the fact that certain very malignant tumors metastasize exceedingly early, we may understand how impossible it is ever to say positively that no metastasis has occurred. Metastases occur doubtless with far greater frequency after an encapsulated tumor destroys its capsule, but the possibility of metastasis during encapsulation cannot be doubted, as even benign tumors occasionally are widely distributed by this process.

The metastases of sarcoma may be few or numerous and of varying size. Occasionally the first evidence the patient has of a malignant tumor is the appearance of secondary tumors, or of some accident such as spontaneous fracture made possible by such a tumor. The cell type of secondary tumors is, of course, identical with that of the parent growth.

The lodgment of malignant tumor-cells at a point remote from the primary growth does not signify necessarily that they must begin at once to proliferate. They may remain dormant for a large number of years and develop into a tumor of the same type as the original, with no evidence of recurrence *in situ*. Hence, the necessity for a period of three to five years after operation before a sarcoma patient can be reported as cured. And cases of recurrence after the five-year limit are seen occasionally.

It has been too universally emphasized that sarcomata do not produce glandular enlargement or metastases. As a rule, they do not, but exceptions are sufficiently numerous to warrant a pretty constant outlook for such cases. From the structural standpoint small round-celled and melanotic sarcomata invade the lymph-nodes secondarily more frequently; the last-named type usually produces lymph-node involvement, and lymphosarcoma habitually. While a rare case of lymph-node metastasis may be seen elsewhere, generally speaking, the most common sites in which sarcomata are productive of such lesions are the tonsil, the testicle, and the thyroid gland. In these structures the lymph-nodes should be investigated as thoroughly as in cases of cancer.

Sudden Enlargement.—A very significant phenomenon occasionally observed in sarcomata is the rapid or sudden increase in the size of the tumor, an increase which could not be due to cell proliferation, owing to the suddenness of its appearance. It is due to hemorrhage into the tumor mass, and this hemorrhage occurs spontaneously or as the consequence of an injury. It is not unusual to find medium or small hemorrhagic spots on the cut surfaces of sarcomata. The explanation of this tendency in sarcoma is easily found by considering for a moment the structure of the tumors and the relation of the blood-supply to the tumor parenchyma.

Pain.—I have already discussed pain in malignant tumors generally. It is only necessary here to emphasize those statements in their especial relation to sarcoma. It has been impressed upon the mind of the laity and of the medical profession that sarcomata are essentially, inherently painful; but they are not, and it may be stated emphatically that the majority of them never produce pain until they are well advanced, except as the result of pressure on sensitive structures, or by virtue of some complication or accident, such as inflammation, ulceration, or torsion. Later some pain or, rather, discomfort may attend them, but painful sarcomata of the soft structures are rare. On the other hand, sarcomata arising in bone may be excrutiatingly painful from a very early period, and they are usually passed by with a diagnosis of rheumatism and a prescription of salicylates until the local signs of tumor formation force themselves upon the observer. In the acute forms of sarcoma the general and local behavior may be very similar to that of inflammation.

Cachexia.—Another late symptom is cachexia. It invariably appears in cases allowed to take their course, but it appears late—*i. e.*, after the tumor has advanced far enough to make severe inroads on the patient's vitality or after the advent of complications. Hemorrhage, ulceration, and infection hasten the appearance of this symptom. When cachexia plainly shows its presence it is very late or too late to offer much hope. The majority of sarcoma cases present themselves while still in robust health.

Fever.—The temperature may rise and run an irregular course. This symptom is seen in sarcoma of the viscera with sufficient frequency to render it of slight diagnostic value. It occurs also in acute, rapidly growing sarcomata, and at times in sarcoma of the osseous system. The temperature usually, when elevated, ranges from 100° to 101° F., sometimes reaches 103° F., and rarely 104° F.

In acute sarcomata there will often be observed a local rise of temperature which may with the other local symptoms cause confusion in differentiating the condition from an acute inflammation.

Bilateral Sarcomata.—Occasionally two sarcomata are seen to arise at about the same time or in moderately close succession, but apparently independent of each other. This is observed more frequently in certain paired organs, namely, testicles, ovaries, eyes, kidneys, adrenals, and crura cerebri. This renders it necessary to examine the organ of the opposite side with especial care before rendering an opinion.

Urinary Findings.—Occasionally the appearance of melanin in the urine or the discovery of melanogen during urinalysis serves as the first true evidence pointing to the diagnosis of melanotic sarcoma. However, since these appear, as a rule, on the surface of the body, such evidence would be superfluous except in concealed tumors.

Diagnosis of Special Forms of Sarcoma.—It is important at times not only to know that a sarcoma is present, but to know to which type it belongs. This can be done satisfactorily in many instances, while in others it is impossible. We must content ourselves usually with the diagnosis of sarcoma without being able clinically to say what type of cellular structure it has. Fibrosarcoma is the form commonly appearing in the soft structures and often, too, arising from bone, periosteum, or cartilage, and can be recognized by the symptoms and signs already given for sarcoma in general.

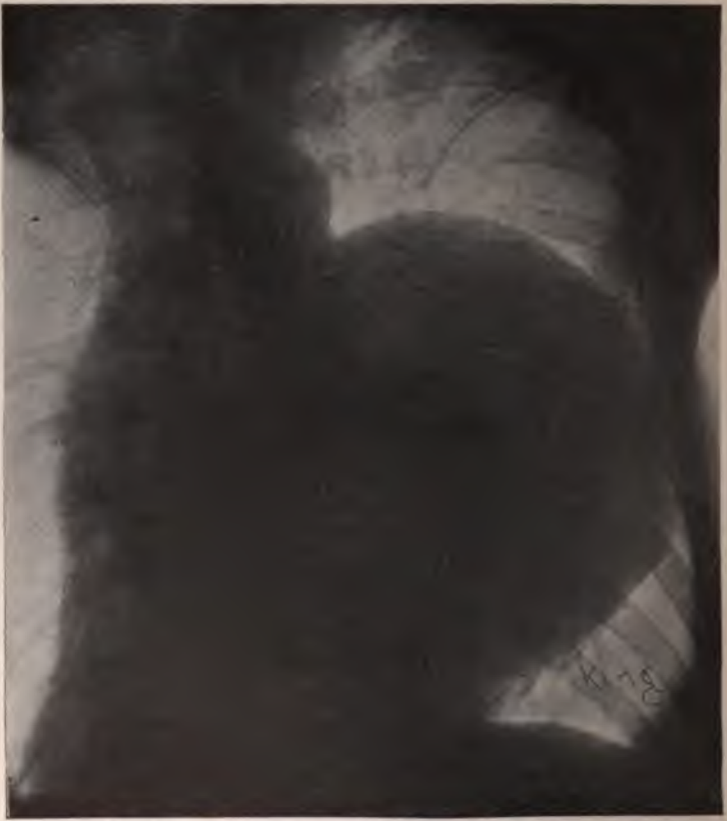


Fig. 160.—Osteosarcoma arising from spinal column.

Chondro- and osteosarcoma, by which is meant sarcomata containing these histologic elements, usually arise from bone, cartilage, or periosteum, although they occasionally appear as heterologous tumors. Their recognition depends upon the presence of factors which indicate their malignant nature plus the evidence of the presence of bone or cartilage. The osseous and cartilaginous elements are often so outnumbered by the cellular elements that no clinical evidence of the presence of the former can be had. A skiagraph will frequently be of service in recognizing the presence of these denser structures.

They appear usually in the long bones and, by preference, at their extremities, in the scapula and clavicle, in the ossa innominata, the sternum, and the skull.

Myxosarcomata are more likely to be confused with suppurative and tubercular lesions and with cysts than any other form of sarcoma, owing to their consistency. When they grow larger and infiltrate the surrounding structures their recognition is easier. They are found quite frequently in the very young (sometimes from the umbilicus) and are sometimes congenital. Their distribution in the body is extensive, although they arise more frequently from the skin, subcutaneous tissue, and the fibrous tissue forming the septa and fasciæ. They often arise from the nerves where they may be multiple, or from the meninges, and from periosteum and marrow.

They arise by preference from the arm, buttock, and thigh, and are especially frequent in the lower end of the femur, just above the knee. The testicles, ovaries, lungs, liver, and kidneys may give origin to them, other organs less frequently. Their nature may be sometimes recognized by aspiration, but the practice is not warranted.

Lymphosarcomata are recognized by their location and the manner of growth. They arise from pre-existing lymphatic tissue, usually in the regions abundantly supplied with lymph-nodes. They are, therefore, more frequently found in the neck, axilla, mediastinum, and abdomen. They may originate in the thymus, the tonsils, from the lymphoid tissue of the alimentary tract, and, rarely, from the marrow of bones. They appear with the ordinary characteristics of fibrosarcoma, but after the surrounding lymph-nodes are invaded and prior to the coalescence of the group into an indistinguishable mass they can be recognized by palpation. Even then the infiltration of surrounding structures will scarcely leave a question of its sarcomatous nature. The tumors tend to ulcerate when situated near the surface. The condition may be confused with pseudoleukemia prior to infiltration of the perinodular tissues; a blood examination, however, will clear the diagnosis unmistakably; besides, the courses of the two diseases are so different as to render them easily distinguishable in most instances.

In connection with lymphosarcoma it is necessary to mention myeloma, which appears in two forms, the first passing under the name of giant-celled myeloma, and the second under the name of myeloma multiplex, or myelomatosis, and chloroma. The classification of these conditions with sarcomata is seriously questioned by many pathologists, and their general behavior as well as their structure unquestionably warrants such doubt. Inasmuch as they affect the osseous system altogether, they will be more fully discussed under Sarcoma of Bone.

Pigmented Sarcomata.—Since they occur usually on the cutaneous surfaces, in the eye, and occasionally on the mucous membranes of the apertures of the body, these tumors are easily recognized by their color, and, in addition, the usual characteristics of sarcomata, of which they represent the most malignant form. They frequently originate from pigmented moles and nevi. It must not be inferred from this, however, that they arise solely from pre-existing lesions. When originating *de novo* they appear as discolored bluish or brownish growths whose color is manifest through the overlying whitish cuticle. Their color may be uniform or mottled and may vary from a brown to a jet black. They usually protrude abruptly from the surface, when they begin to grow rapidly and are often pedunculated. They are prone to ulcerate and bleed, and, of course, are then subject to infection and emit odors of decomposition. The discharge from their surface often stains the dressings with the contained pigment. Glandular involvement takes place early once the tumor reaches a stage of rapid growth, which often occurs after the capsule is ruptured by growth, by accident, or meddlesome or imperfect treatment, such as ligation of the pedicle of a mole or incomplete destruction or removal by cautery or knife. It should be emphasized again that incomplete surgery on pigmented growths is, of all, the most unpardonable. Soon after the tumor begins a rapid growth numerous nodules appear in the tegument surrounding it, and remote metastases are early and rapidly produced. Usually the metastases are pigmented just as the primary growth, but non-pigmented growths may form a certain percentage of the secondary tumors. The blood may show evidence of the pigment (melanemia), the urine may be discolored with melanin or contain melanogen, and in rare instances the tissues of the body generally may be discolored. Melanotic sarcomata occur at any age, and may appear on any part of the body surface, though with greater frequency in the regions most abundant in pigmented growths and in the eye, and are especially likely to arise on the face and the upper and lower extremities.

Microscopic Diagnosis.—No tumor should be treated by the radical measures required in cases of malignancy until it has been definitely and unquestionably settled that it is malignant, and, if possible, what the degree of malignancy is. On the other hand, no tumor that bears any suspicious marks, whether they be due to its position or its behavior, should be allowed to continue untouched until it manifests its true nature in a clinical way. This can be done only with a microscope and by a competent pathologist, for it is often extremely difficult to differentiate sarcomatous tissue from other lesions, and sometimes impossible unless the gross specimen or the clinical behavior be taken into consideration. Two plans are employed for this purpose, each applicable in certain instances. It is preferable to prepare the patient for operation, remove the tumor *in toto*, if possible, and turn it over to the microscopist for immediate examination by the frozen method. Ten to fifteen minutes will be required for a report, during which time the patient is lightly held under anesthesia. If the report is positive, radical work may proceed; if negative, the wound is closed and the negative findings should be confirmed by the slower and more accurate processes of hardening. If the tumor cannot be removed, it is necessary to remove a section for examination. This section should come from the newer, rapidly growing portion of the tumor, and if possible the circulation should be shut off from the region by a tourniquet or otherwise, for there can be no doubt that cells may be liberated by this procedure which develop into remote metastases long after a satisfactory operation has been done. The same danger is to be remembered in connection with aspiration of the tumors in the hope of recovering diagnostic material. The second plan is the so-called slow method, which is unquestionably more satisfactory in many ways. However, the tumor should, when it is feasible, be removed as a whole or should include with it more or less of the surrounding tissues. The slow method is especially objectionable when only a part of the tumor is excised, since the blood-supply cannot be permanently shut off and metastases have all the better chance to occur.

Sarcoma of Special Structures and Organs.—*Alimentary Tract.*—The stomach is rarely affected by sarcoma, primary or secondary. When primary sarcomata appear they usually come in the muscularis, submucosa, rarely from the mucous membrane, and therefore may appear as intramural, internal or external. The latter is occasionally pedunculated; otherwise they are usually non-pedunculated tumors. Those found in the muscle are usually round-celled, those arising from the mucosa and submucosa are round-celled or lymphosarcomata; the latter often lining practically the whole of the stomach with tumor nodules; those formed from the submucosa are round- or spindle-celled or myxosarcomata. Sarcoma of the stomach is found more frequently between the ages of forty and fifty, although no age is exempt, and lymphosarcomata are especially favored in the earlier years of childhood. The intramural round-celled tumors may grow rapidly, become cystic, rupture into the cavity of the stomach, and suppurate abundantly. Occasionally fibromyoma of the stomach becomes sarcomatous. Usually sarcomata of this organ are of average consistency, although they are sometimes supplied with abundant fibrous tissue (fibrosarcoma) and may be very hard. They can usually be distinguished fairly well macroscopically or microscopically from carcinoma, but round-celled tumors of the inner layers when they infiltrate the walls extensively put both the pathologist and the microscopist to a severe test to differentiate them from carcinoma. Sarcomata of the stomach rarely result in stenosis and are less disposed to ulcerate than carcinomata, and, as a rule, do not so rapidly produce death.

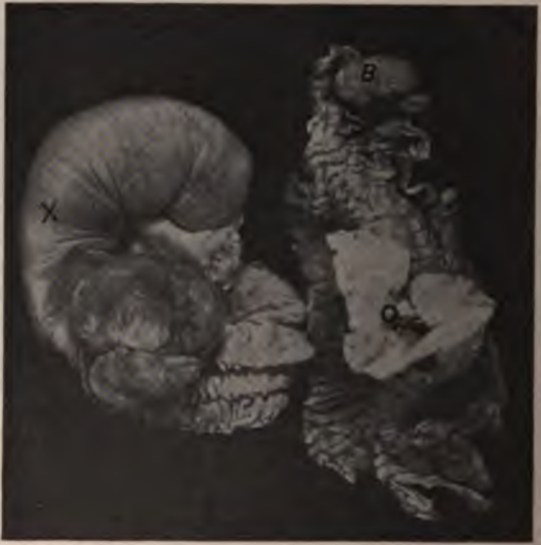


Fig. 161.—Multiple myxosarcoma of intestine. In *X* there is intussusception due to large mass—about the size of a baseball. First symptom was "locked bowels" seven days before death. At *O* is a mass cut open. At *B* is a smaller tumor.

Secondary sarcomata of the stomach are usually multiple, melanotic tumors, or non-pigmented, round-celled tumors; rarely they are spindle-celled. The secondary tumors are usually nummular and situated in the mucosa or submucosa, with their surfaces often more or less cupped.

Sarcomata are rare in the intestines. They occur three times as frequently in males as in females. They are more often found in the terminal extremity of the small intestine and in the cecum, very rarely in the appendix. The types chiefly found are round-celled (occasionally alveolar), less frequently spindle-celled, and melanosarcoma, the latter appearing only in the rectum. Lymphosarcomata occur in both the small and large intestine, preferring the former. Primary sarcoma of the intestines is usually a single tumor, very exceptionally multiple; lymphosarcoma is more frequently multiple than the other types. Sarcoma may arise from mucosa, submucosa, or muscularis, grows as a stenosing mass, involving the whole circumference of the gut, or sometimes affecting only a portion of the circumference, when it may be pedunculated and behave as a polyp. They may be the cause of

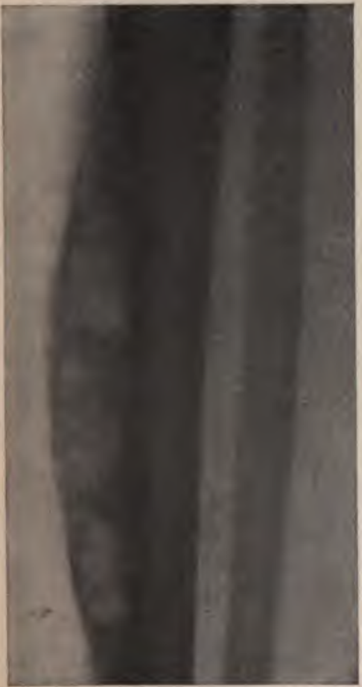


Fig. 162.—Myxosarcoma of bone.

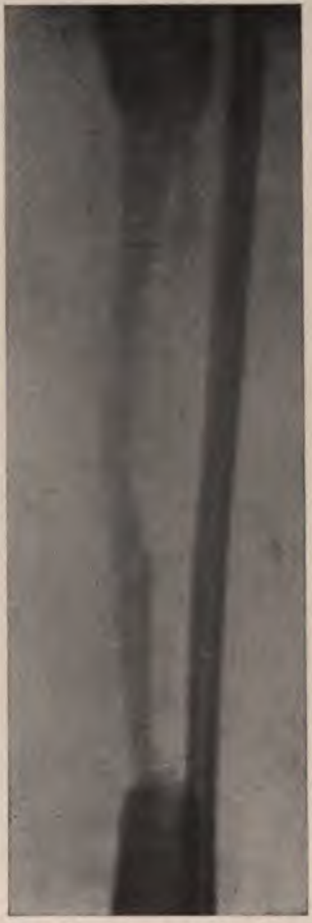


Fig. 163.—Same as Fig. 162, six months after resection and transplantation of portion of other tibia.

intussusception before reaching a large size. They are found in all ages and may reach an enormous size, especially when arising from the large intestine. They are prone to ulcerate and become necrotic or degenerate. They can often be distinguished from carcinoma only by microscopic examination. Lymphosarcomata infiltrate the wall more extensively and may involve a considerable length of the gut. This type often invades the peritoneum and is very apt to produce numerous remote metastases at an early stage.

Metastatic sarcomata of the intestines occur somewhat more frequently than primary. They are found in the muscularis, submucosa, in the peritoneal covering, the appendices epiploicæ, and at the mesenteric attachment. They are more often melanotic, seldom disposed to ulcerate, and occasionally produce obstruction by bulging into the lumen of the gut. When ulceration occurs, and the tumor infiltrates and more or less completely encircles the gut, they resemble carcinoma very closely.

Bone and Periosteum.—I have said already that primary sarcomata of bone and periosteum may be either osteosarcoma or chondrosarcoma, or, on the other hand, be of any of the soft varieties except melanosarcoma. Hence, it must be emphasized here that many sarcomata arising from bone, periosteum, and cartilage are not possessed of the power to form bone or cartilage as the tumors grow, but are at their beginning and remain soft and flesh-like in their consistency, as those arising from fibrous tissue rests in the soft parts, which are hence called fibrosarcomata.

Periosteal sarcomata appear by predilection near the ends of the long bones, especially the lower end of the femur and the upper end of the tibia and humerus, but are by no means confined to these sites. They are usually round- or spindle-celled tumors, but may be mixed celled or giant celled. They are usually firm tumors, but may be extremely soft; they occasionally assume the form of chondrosarcoma or of ossifying sarcoma (osteosaroma). The growth may assume more or less a spindle shape and gradually surround the bone. The bone beneath a periosteal sarcoma is sometimes so completely destroyed by the growth of the tumor and its infiltration of the bone that a spontaneous fracture results. On the other hand, there may develop an ossifying osteomyelitis, which adds to the density of the bone until it acquires the hardness and solidity of ivory; as periosteal sarcomata increase in size they may infiltrate the surrounding periosteal covering and invade the surrounding soft structures just as sarcoma of the soft tissues. The metastases from periosteal sarcomata, more common by far in the lungs, may be of the ossifying type or soft, and show only partial calcification of their substance.

A very common form of periosteal sarcoma is seen in the form of epulis which arises from the periosteum covering the alveoli, usually of the lower jaw, and runs a rather benign course as a rule. It may be a pedunculated or sessile tumor and frequently originates between two teeth. It is made up of spindle cells with a varying admixture of giant cells. Occasionally it contains bone, although it does not become completely ossified.

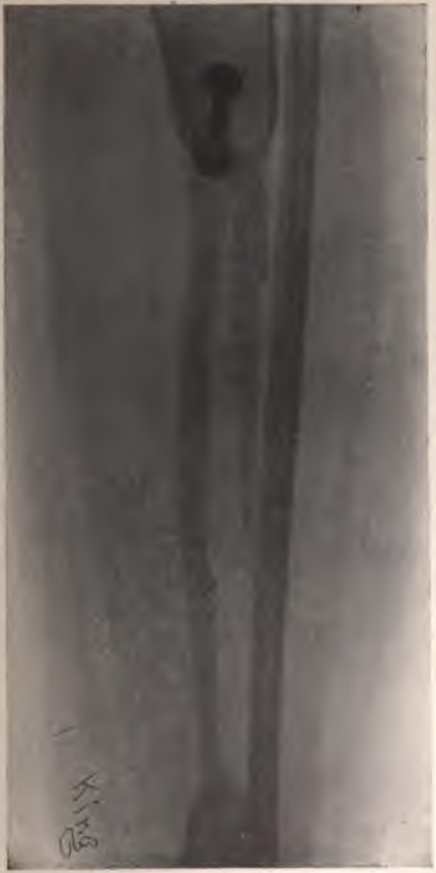


Fig. 164.—Skiagraph of leg ten months after transplantation of graft from opposite tibia. The upper end of graft failed to unite and required the employment of a Lane's plate.

In periosteal sarcoma metastases are likely to occur relatively very early, and the tumors are, as a rule, very rapid in growth. There is danger of confusing the diagnosis with syphilitic lesions and especially with tuberculosis, which cannot always be cleared up by the Wassermann reaction and the tuberculin tests, for it must be remembered that a syphilitic or tuberculous individual may develop sarcoma. The differentiation is all the more difficult if the lesion is near an articulation. The acute and rapidly growing sarcomata may be confused, too, with inflammatory processes, and occasionally are associated with a continued fever. The continuous growth, the outlines of the tumor, the nodular surface, if present, the continuation of growth whether the part is functionating or at rest—while inflammatory processes, particularly the chronic types, are improved by this treatment—favor the diagnosis of sarcoma. Spontaneous fracture and occasionally spontaneous dislocation are evidence of malignancy, although they are not to be accepted as pathognomonic. The employment of a skiagraph is often of the greatest value in differ-

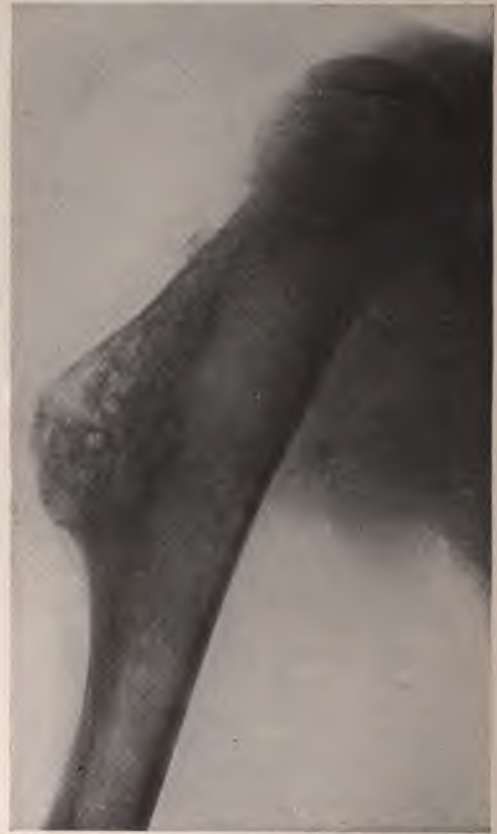


Fig. 165.—Skiagraph of myxosarcoma of humerus in a boy sixteen years old.

entiating sarcoma from other lesions. Myositis ossificans is extraperitoneal and can usually be distinguished if a skiagraph be studied in conjunction with the symptoms and history. Periosteal sarcoma occurs with much greater frequency in the young.

Sarcoma arising from bone is known as myelogenous sarcoma. They are made up of cells of the most varied types, chief of which are small round-celled sarcoma, large round-celled sarcoma, spindle-celled sarcoma, often with a marked variation in the size of the cells in a given tumor or with considerable abundance of fibrous tissue, and there often appear large numbers of enormous giant cells admixed with the spindle or connective-tissue cells, the most perfect examples of giant-celled sarcoma. Sometimes the cells are alveolar, as also the periosteal tumors may be. There frequently appear large numbers of blood-vessels in the substance of myelogenous sarcomata, telangiectatic or hemangiosarcomata, which may pulsate and cause confusion with bone aneurysms; frequently, too, they produce a bruit not unlike that so characteristic of aneurysm. The sites of predilection are, above all, the lower jaw, then the upper jaw, the epiphyses of the long bones, especially the tibia and the bones of the forearm. Occasionally the

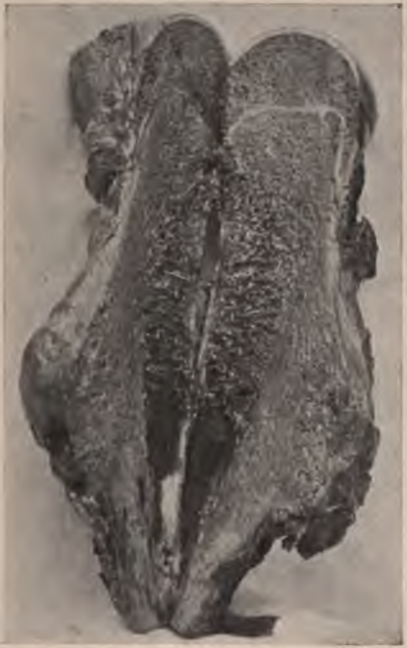


Fig. 166.—Photograph of excised bone. Same as shown in Fig. 165.

diaphyses are affected. Many epulides are of the myelogenous, rather than the periosteal, type.

Myelogenous sarcomata may gradually enlarge and, while destruction of the original normal bone takes place, form a shell of bone over their surface which may be so thin as to crackle under moderate pressure, the so-called parchment crackling. Cyst formation is not uncommon, and many of the bone-cysts reported are due to this origin, as has been revealed by finding the characteristic sarcoma structure in the thin cyst walls. Retrograde changes are common and hemorrhage into the tumor substance frequent. The tumors are sometimes myxomatous. Bone forms often in the substance of the tumor and often assumes the form of a large number of spicules (needles) radiating through the tumor mass, or, in cystic sarcomata, they form osseous septa separating the various pockets of the multilocular growth from each other. Spontaneous fracture is occasionally a symptom, and is more likely to occur in the soft non-ossifying myelogenous sarcomata. Osteosarcomata are very rarely congenital.

Pain may be the first evidence that the host of a bone sarcoma is diseased, and usually is interpreted as rheumatism or neuralgia, although no other symptoms of these conditions are present, and although the simple resort to skiagraphy would lend the most valuable evidence.

Myelogenous sarcomata are to be accepted as among the most benign, taken as a group; this is especially true of the giant-celled tumors or myelomata. Unlike the periosteal type, they are little disposed to infiltrate the surrounding tissue, although they may do so; and are very prone to produce no metastases, which when they do occur are more abundant in the lungs. They often grow directly into the veins of an extremity and then indefinitely along their lumina, a frequent cause of recurrence after amputation. Hence, in every instance of the kind the veins should be investigated thoroughly before an opinion is ventured concerning the prognosis. The myelogenous epulides may be said to be entirely free from a tendency to produce metastases, although they are likely to return *in situ* after removal. It is true in myelogenous sarcoma, however, as it is in general, that the malignancy of the tumor, its power of infiltration, its disposition to metastasis is largely determined by the size of its constituent cells, the smaller cells being much more dangerous. Hence, surgeons have come to recognize in their practice the relative innocence of those myelogenous tumors whose cells are large and which show a great proportion of giant cells, and are modifying their methods of treatment accordingly along much more conservative lines.

Occasionally primary multiple myelogenous tumors occur in the bones, especially in the femur, the ribs, the sternum, the vertebral column, and the skull. These may be either lymphosarcomata, which are truly malignant growths capable of metastasis, or the genuine myelomata, which arise only in the red marrow and produce no metastasis. These primary multiple bone tumors may cause extensive destruction of bone. The presence of these tumors is indicated by the appearance in the urine of Bence-Jones bodies, a reaction which is found also in cases of lymphatic leukemia.

Secondary sarcomata of the skeleton are chiefly melanotic sarcomata, derived, as previously stated, from primary tumors situated usually in the skin. Rarely an osteosarcoma produces practically all its metastases in the skeleton.

Brain, Cord, and Meninges.—These structures are rarely the site of primary sarcoma, and the tumors cannot be differentiated from other lesions which similarly produce pressure on the central organs of the nervous system. The bony encasements, the periosteum, and the meninges are affected by sarcoma much more frequently than the brain and cord, which, however, may give origin to spindle-celled or mixed-celled tumors and to angiosarcoma. They arise from the connective tissue of the blood-vessel supply. Sarcomata cannot ordinarily be distinguished macroscopically from gliomata unless metastases have occurred in the brain or remotely, or unless the tumor has shown evidences of infiltration.

Kidneys.—Sarcomata of the kidneys occur with considerable frequency in the very young and are sometimes congenital. They are capable of attaining an enormous size, records of tumors weighing 25 to 30 pounds having been made. These large tumors present in the child an appearance of the abdomen very similar to that produced by enormous cysts in adult women. They are very apt to be bilateral, so that one can offer little assurance aside from the mortality from the operation. The tumors are usually very soft and vascular. These tumors of the newborn contain glandular elements and may show striated muscle-fibers. They have thus been spoken of as adenosarcomata or adenomyosarcomata. The sarcomata which are found in children also often contain adenomatous elements.

Sarcomata of the kidney in the adult are less frequent and not so apt to be bilateral. They are either round or spindle celled, the former soft, the latter more firm. It is often necessary to distinguish sarcoma of the kidney in the adult from carcinoma, and this can be done clinically only when the disease has declared itself positively. Sarcomata grow to a larger size than carcinomata. Pain is present in both, and hematuria is present in a large percentage of cases, manifesting itself as soon as the pelvis is invaded.

Hypernephroma is a term employed to cover several forms of tumor originating in the kidney from presumably misplaced rests of adrenal (hypernephric) tissue. The term embraces a benign and malignant type. The exact position of these growths in the classification of tumors is much disputed. The benign form is usually given as a type of adenoma. The malignant type, which especially concerns us here, is classed as alveolar or angiosarcoma, as perithelioma, and recently, by Stoerck, as carcinoma. Their true nature cannot then be asserted, although the majority have doubtless considered them sarcomatous. They are found more frequently in the sixth decade of life. They grow more slowly, as a rule, than either carcinoma or sarcoma. The tumor when large often appears nodulated. Pain develops in most cases as the tumor enlarges; it is not a constant symptom. Hematuria is often the first and may be accepted as the most distinctive symptom.

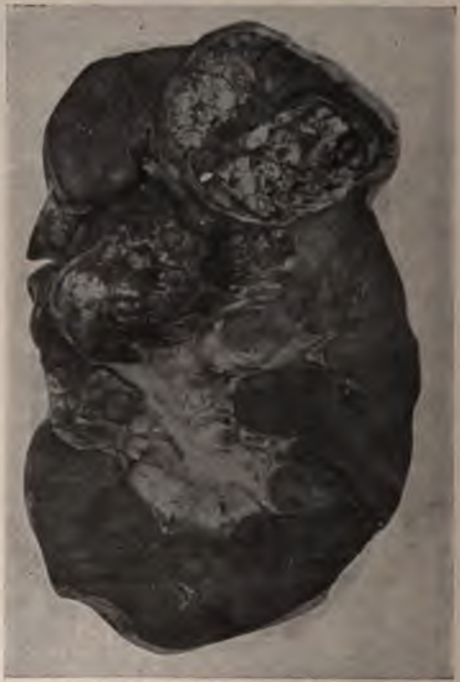


Fig. 167.—Hypernephroma. Tumor growing into pelvis of kidney. Observe capsule of the tumor.

Whether sarcoma or hypernephroma be the tumor in question, there are certain pathologic and clinical facts to be noted. The tumor may originate within the kidney substance and grow to a size (that of an adult's head) and be mistaken for the primary growth, unless a most exhaustive examination be given. Usually metastatic sarcomata of the liver grow as isolated masses easily distinguishable from the surrounding tissues, but they occasionally infiltrate the surrounding zones, sometimes appearing in a radicular form, owing to their manner of spreading in the vessels.

Lungs.—Primary sarcoma of the lungs is exceedingly rare, but may attain an enormous size and infiltrate the entire organ. It can rarely be diagnosed by microscopic examination of the sputum.

Secondary sarcoma of the lungs, on the contrary, is exceedingly common, especially when the primary growth is situated in certain organs. (See Sarcoma of the Kidneys, Periosteum, etc.)

Omentum.—Sarcoma of the omentum is rare. It may occur as a single large mass, or the whole omentum may be studded with nodules and "resemble a cherry pie." They are fibro- or myxosarcomata and are spindle celled in more than half the cases.

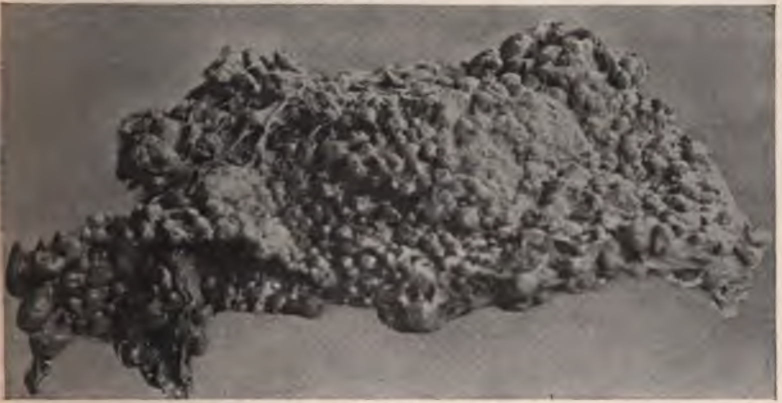


Fig. 170.—Sarcoma of great omentum.

Ovaries.—These organs are rarely affected by sarcoma. The tumors are usually spindle celled, but round-, giant-, and mixed-celled tumors are occasionally observed. Myxosarcomata may be found, and this organ is one of the rare sites serving very exceptionally as the site of a primary melanosarcoma. Sarcocarcinoma, cystadenosarcoma, and adenosarcoma are sometimes observed. The tumors occur in young women especially, but are relatively quite frequent in children and rare in the fetus; in either instance they may be bilateral.

They are likely to be of the alveolar type in the very young and thus come to resemble cancer microscopically. The tumors are usually firm, nodulated or smooth, oval or oblong; but may be soft, rapidly growing (round celled), and very malignant. Cystic degeneration is frequent. Sarcoma of the ovaries is most common in children, rare between the sixteenth and twentieth years, more frequent again between the ages of twenty and thirty, less frequent then till the menopause, and after this again more frequent. They are usually unilateral after the twentieth year (Bland-Sutton).

Secondary sarcoma of the ovaries is infrequent.

Pancreas.—The pancreas seldom gives rise to sarcoma in the primary form. However, metastatic growths are more common, and chief among these are metastases from melanotic primary tumors.

Parotid Gland.—The appearance in this gland of pure sarcoma or of tumors containing sarcomatous elements is quite frequent. They may be purely round- or spindle-celled sarcomata. Occasionally pigmented sarcoma, myxosarcoma, chondrosarcoma, or osteosarcoma is observed. Sarcomata of the parotid, pure or mixed, are to be classed among the most benign of malignant tumors. They are usually encapsulated, slow-growing, and easily enucleated, with little danger of recurrence.

Retroperitoneal Sarcoma.—This is the most common form of retroperitoneal and mesenteric tumors. They are usually spindle celled; lymphosarcoma, myxosarcoma, liposarcoma, and cystic sarcoma have all been observed. The tumors appear either distinctly behind the peritoneum or in the mesentery. They may attain an enormous size. They are, as a rule, encapsulated; metastases are found in about one-half the cases. Retroperitoneal sarcomata occur usually after the age of thirty and before the age of fifty years. They are not unknown to children.

Spleen.—This organ is among the rarest structures affected by primary sarcoma, but it is interesting to note that it may be the site of origin of angiosarcoma. Secondary tumors, though still rare, are more frequent than primary, and among them melanotic metastases and lymphosarcomata stand out prominently. The melanotic tumors appear as round, mottled, or black nodules distributed throughout the organ.

Testicles.—Sarcomata of the testicles occur with moderate frequency. They are of various types; round celled and spindle celled predominate. Giant cells are often found associated with the latter in connection with striated muscle-fibers. Pigmented tumors and lymphosarcomata are occasionally seen. Cystic sarcomata are formed by cystic dilatation of the canals of the organ, or intracanalicular sarcoma by invasion of these canals and the formation of nodules in them. Adenosarcoma, adenocystosarcoma, and carcinosarcoma may be found. The mixed tumors are found in a considerable percentage of the cases.

Cases of angio- and myxosarcoma of the testicle have been reported. The spindle-celled tumors are firmer than the round celled. Sarcoma of the testicles may occur at any age and are often bilateral. They may amalgamate testicle and epididymus into an indistinguishable mass, or they may gradually push aside the testicular substance so that it forms a thin ensheathing wall. The tumor may grow along the cord, causing enlargement of it and loss of pliability. Sometimes, though rarely, the growth causes rupture of the tunica vaginalis testis and the skin, appearing on the surface as a raw, easily bleeding fungoid mass—fungus sarcomatodes. The tumors may reach a large size, especially if cystic. Metastases may occur through the blood, but lymph-node involvement is rather the preferred route of extension, and is explained by the growth of the tumor-cells into large lymph-spaces, whence the cells may be carried along the cord to the lumbar nodes. The whole chain of lymph-nodes from the lumbar to the upper dorsal may be invaded. Degenerative changes, such as fatty or mucoid degeneration, calcification, and hemorrhage, are frequently seen in sarcomata of the testes. Trauma is cited as the exciting cause of testicular sarcoma in nearly half the cases.

Thyroid.—The appearance of sarcoma of the thyroid (struma sarcomatosa) is usually in the form of an isolated mass. It may be situated in either lobe or in the isthmus. Sometimes it appears as a diffuse mass. It is round, spindle, or mixed celled and may show giant cells. Osseous and cartilaginous elements are sometimes found. The tumors may grow with incredible rapidity, and this is accelerated by the frequent occurrence of hemorrhage. Sometimes they grow slowly and may be described as chronic. Still a third group may be mentioned, in which the primary growth escapes notice until the appearance of metastases. Sarcoma of the thyroid is slightly more frequent than cancer. It occurs sometimes in the young, and is more common in goiter districts; however, its greatest incidence is in old goiter cases, in whom the age of greatest liability is between fifty and sixty years.

The tumors may produce lymph-node involvement, invade the veins and infiltrate the surrounding muscles, the skin, or the trachea and larynx, or the growth may produce compression of the trachea or interfere with the function of adjacent nerves by pressure or infiltration. Death may result from edema of the glottis. Metastases occur most frequently in the lungs, with the osseous system second in frequency.

Uterus.—Sarcoma of the uterus is usually seen in the body, less frequently arising from the cervix. In the body the tumors arise either from the musculature or from the endometrium. Those arising in the musculature often are consequent upon myofibromata. The endometrial type is usually a diffuse growth which sometimes appears in the form of polypi in the uterine cavity. Multiple nodules may be seen in the form of a cluster of grapes. Discharge of tumor lobules may take place *per vaginam*. The tumor may invade the musculature and widely infiltrate it, passing ultimately to the peritoneum. The muscular types are less likely to be diffuse, and appear as roundish, nodular masses, which are firm; but when they are diffuse they may attain very great dimensions. Metastases are not especially frequent. The tumor on reaching the peritoneal surface may invade apposed viscera or become widely implanted on the peritoneum. It is interesting to note that benign tumors of the uterus may be invaded by a sarcoma arising in their proximity. Secondary tumors are more common in the vagina, liver, lungs, and bones.

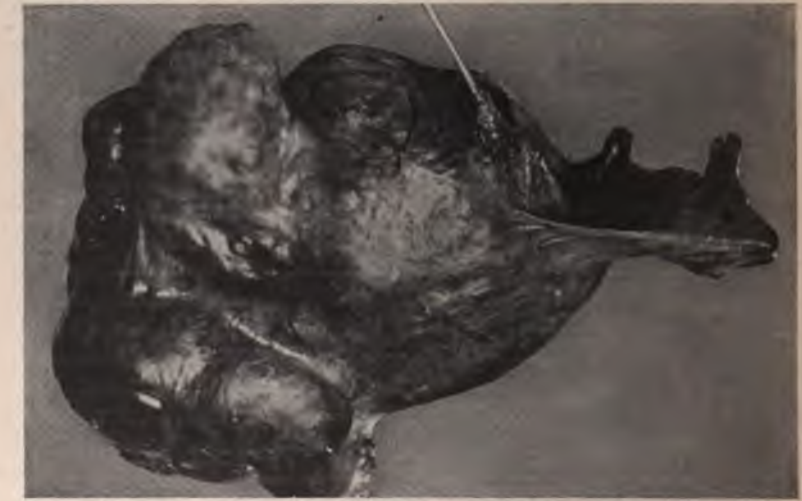


Fig. 171.—Enormous sarcoma of the uterus. Note sound in uterine canal.

The cervical sarcomata are very apt to appear as polypi and bunched like grapes; they are occasionally edematous. They are usually spindle- or giant-celled tumors, and are soft, growing with great rapidity. They are very apt to recur locally after removal, and when they protrude into the vagina their surface may become raw and cause a foul suppurative discharge. Myxosarcoma, adenosarcoma, carcinosarcoma, and lymphangiectatic sarcoma have been found occasionally.

Cut-surface Appearance.—The appearance of sarcomatous cut surfaces is variable on account of the great variety of structure, and owing to the accidents and degenerative changes to which they are subject. The surface is white or gray or reddish gray in the majority of cases and may show a suggestion of translucency. In the firmer tumors the cut surface is more nearly white. If melanin is present in considerable quantity the surface is mottled or brown or black. Hemorrhages into the substance of the tumor are very common; they may be minute and numerous, or large, causing a very characteristic discoloration of the surrounding tissues. The multiple minute hemorrhages give, too, a mottled appearance which, owing to its consistency and color, will not be readily confused with melanotic spots. The cystic tumors present sometimes walls of such thickness and appearance as to leave little doubt as to their true nature; but in thin-walled cystic sarcomata, which constitute a considerable percentage of bone-cysts, the true nature can be gathered only by careful microscopic investigation. The appearance of bone, cartilage, lymphangiectatic, telangiectatic, or other tissues should not mislead; they may be present, but the true nature of the tumor is to be sought in the solid tissue surrounding these.

Pathologic Changes.—The great variety, the frequency, and the early advent of degenerative and other secondary changes occurring in sarcomata make them an important factor in their study. These degenerative changes are more likely to occur in the older parts of the tumor, and may so alter it as to render it entirely unlike the unchanged tumor substance. Fatty degeneration is common and may result in the formation of pockets of fluid (cysts) in the substance of the tumor. Aside from myxosarcoma, and independently of it, myxomatous degeneration is a very common change, in which a mucoid substance replaces the cells, the intercellular substance, and the connective tissue. This can be distinguished from myxosarcoma by its appearance in spots in the older part of the tumor, while the distribution is uniform in myxosarcoma and is coincident with the formation of the cells—*i. e.*, it is a part of the growth. The degenerative changes may be so rapid, compared with the growth of the tumor, as to give it the appearance of a cyst pure and simple with a wall of variable thickness. Fig. 146 illustrates a large cystic sarcoma in which the secondary nodules no larger than a hen's egg were already beginning to show cyst formation in their center. Caseation is said to have been observed in sarcomata; it is probably due to the action of tubercle bacilli. Hemorrhage from the ulcerated surface of the tumor may occur, but is not so common as in cases of cancer. It is very common in the tumor substance, whether the tumor has been traumatized or not. It may be in sufficient quantity to cause sudden enlargement of the tumor, or be small and appear at various points; in cutaneous or subcutaneous sarcomata it may produce distinct discoloration of the skin. The hemorrhage may be absorbed or result in cysts. It produces discoloration of the tumor tissue surrounding it. Suppuration occurs in the ulcerative cases, and together with hemorrhage and the continued serous discharge from such surfaces hastens or intensifies cachexia.

The development of cartilage or bone in sarcomata occurs usually in those tumors arising from cartilage, bone, or periosteum, occasionally in structures which normally have none of these elements, such as kidney, testicle, or lung. A most common form of ossifying sarcoma is epulis.

Prognosis.—Considered in a general way, it may be stated that the prognosis of sarcoma untreated is altogether bad, although there are certain forms that are comparatively benign. The time from the appearance of the tumor till the death of its host is, on the average, from eighteen to thirty months, if we leave out of consideration the more benign forms alluded to above. The small-celled tumors are usually more rapid than the large celled; the small round-celled tumors are the most rapid, and may be of such quick growth as to be mistaken for inflammatory processes. Giant-celled sarcomata are the least malignant and the spindle-celled tumors are intermediate. The presence of melanin in a sarcoma intensifies its malignancy from the dangers of both metastasis and lymph-node involvement. Melanosarcomata of very small proportions and devoid of symptoms may sink into insignificance in comparison with the widespread and fatal metastases, which may, indeed, be the first evidence that the patient has of the presence of such a tumor.

There is a time when every sarcoma may be said to be amenable to curative treatment, although that time has frequently passed when the presence of the tumor is recognized, or the tumor may be so situated that such curative treatment cannot be administered on account of its connection with a vital organ. So long as the cells of a sarcoma are confined to the structure removed at operation it is curable, necessarily with the sacrifice with it of structures of varying importance; but as soon as any number of cells have reached a suitable point for their growth and are inaccessible to removal the case may be accepted as hopeless. All cases of metastases and most, if not all, of local recurrences after judicious removal have an utterly bad prognosis.

In connection with the prognosis it should be impressed that one has no justification for suggesting a favorable outcome until a thorough examination has been made of the whole body.

The malignancy of tumors appearing in certain organs and the dangers of recurrence in the paired organs already mentioned demand a very guarded prognosis when such structures are affected.

The more benign forms—myeloma, epulis, and the mixed tumors so frequently found in the parotid gland—in the majority of cases offer, with reasonable judgment in their treatment, almost as good chance of recovery as if they were really benign.

The outlook of sarcoma is such as to require the physician in attendance to keep track of the case with thorough examinations at intervals of one to three months for a period of years. No case of sarcoma can be legitimately reported as cured within a period of three years from the date of treatment, and occasional recurrences after the expiration of this time raises the question whether this limit is sufficiently long.

Treatment.—The first and most urgent fact in connection with the treatment of sarcoma grows out of the statement that the tumor may at any moment become incurable, if, indeed, it has not already done so. Therefore, as soon as a questionable tumor presents, it should be attended to with immediate despatch, time being taken only for a careful preparation of the patient and for positively settling the question of malignancy. This duty rests heavily upon the physician, owing to the disposition of patients to view with little alarm a tumor that may have given rise to no distress.

The treatment *par excellence* for sarcoma, wherever it may be situated, provided it has not passed all hope of recovery, is surgical removal not only of the tumor, but with it of a sufficiently wide area of surrounding tissue to guarantee against probability of local recurrence; it must be removed in such a manner as to reduce to a minimum the danger of liberating tumor-cells which may escape into the circulation or be left in the wound. If the organ in which the the tumor originates can be safely spared, it should be removed as a whole, unless the tumor be one of the more benign forms. The lumina of the vessels supplying the tumor or the organ containing it should always be carefully inspected to determine whether they have been invaded, and if so, they must, if possible, be dissected out. Likewise, when the growth is of such a type or so situated as to render lymph-node involvement probable, the lymphatics should be dealt with according to the directions detailed under the treatment of Cancer.

It is true that sarcomata while yet small and recent may be removed by wide excision with a fair chance of cure; this plan is necessarily followed in many locations, for example, on the head, neck, or trunk, and may, if careful judgment is exercised, be occasionally employed in sarcomata of the extremities. It is unquestionably safer in the majority of such cases to amputate high above the tumor, preferable leaving no part of the bone in which the tumor originates, unless it be giant celled or myeloma. It is necessary to state that the treatment of sarcoma of bone is being practised along much more conservative lines than formerly, when every such tumor was accepted as an indication for a high amputation; the results obtained, too, justify the conservative plan.

The benigner types of sarcoma are dealt with much less radically than the more rapidly growing, more malignant types. So, mixed tumors of the parotid gland are enucleated with very great safety, and the remaining cavity closed directly or swabbed out with pure carbolic acid or Harrington's solution and closed or packed. Epulis requires removal of the tumor, including the mucoperiosteum from which it arises, or this together with a bit of the alveolus. They do not require resection of the jaw as other forms of sarcomata do. Myeloma receives conservative treatment by resecting that portion of the bone containing the tumor with a moderate length of sound bone above and below, and the periosteum on that side toward which the growth has been directed. The periosteum on the unaffected surface of the bone is left in hope of regeneration, or, if it is considered unwise to leave any portion of the periosteum, both bone and periosteum may be resected and the defect repaired by immediate or future grafting or osteoplasty. This plan is not only applicable to giant-celled tumors and myeloma, but is being successfully employed in the less malignant of other types. Further than this, it may occasionally be justifiable to remove the tumor substance as if it were so much necrotic bone, by scoop and curet, and cauterize the cavity with carbolic acid and pack or close to heal by blood-clot, or, preferably, to fill the space with bone-grafts or Moorhof's bone-wax and close. It must be clear then that no hard-and-fast rule can be laid down for the treatment of sarcoma in general, since its treatment depends upon the cell type, the situation, and the general behavior of the growth. One cannot fail to see how important it is, even admitting the presence of sarcoma, to know just what evidence the microscope gives of the degree of malignancy; otherwise it is impossible to do justice to these cases.

Inoperable Cases.—By inoperable sarcoma is meant one that cannot be removed without resulting in the death of the patient or in which metastases or lymph-node involvement have been so disseminated that its removal is impossible. To this perhaps should be added those cases in which the patient's general condition is so poor that no radical operation can be tolerated.

The management of inoperable sarcoma should be so directed as to give the patient primarily the greatest comfort and prolongation of life. It may become necessary to operate on such for relief of pain, either by excision of the primary growth or by neurotomy, neurectomy, or avulsion of the sensory nerves supplying the region, for control of hemorrhage by excision, or by ligature of the blood-supply. Ulceration and the consequent fetor and discharge of body fluids may also require excision, when there is no hope of cure.

The pain of those who cannot be otherwise relieved should be controlled by liberal administration of opiates; habit in such can be of little moment. The surface infection resulting in suppuration, decomposition, and fetor must be controlled by the local application of antiseptics and deodorants. It is best when possible to remove such tumors.

The employment of Röntgen rays in the treatment of sarcoma may be summarily dismissed as of no curative value, although pain may be alleviated or controlled by this means.

Coley's fluid, made from an admixture of the toxins (culture) of streptococci (of erysipelas) and Proteus vulgaris, has been employed in large numbers of cases; the idea was suggested by the occasional disappearance of a sarcoma when it became infected with erysipelas. The results have been disappointing, for while occasional cures cannot be questioned, they are very few, and while others have been apparently retarded in their growth or reduced in size, they have later on resumed their activity with the usual result. Coley's fluid should, therefore, be employed as the sole reliance only in inoperable or recurrent cases. It may be possible to reduce the number of recurrences by its routine administration after radical operation. The fluid is administered daily or on alternate days. The first dose should be $\frac{1}{2}$ to 1 minim, and each dose increased from $\frac{1}{4}$ to 1 minim until the reaction is produced, shown by a marked rise of temperature, often accompanied by a chill. The administration must be subjected to rigid asepsis, and the doses should be given alternately into the tumor substance, if possible, and in remote parts. It is superfluous to add that this plan can be followed only in a hospital. So long as the tumor decreases in size the treatment is continued. Continued growth, failure to reduce the size and a resumption of growth after a period of reduction, while still under treatment, are indices that the treatment will do no further good.

Myeloma.—Aside from the condition already described as myelosarcoma or myeloid sarcoma, we must notice, in passing, the so-called myeloma, multiple myeloma, or myelomatosis.

Structurally, it has led to the belief that it was a subdivision of lymphosarcoma, although recent studies have led many to the conclusion that the condition is not sarcomatous and that it does not truly belong to the tumor group. Multiple from the beginning, it does not produce metastases or lymph-node involvement. The primary nodules may appear in widely separated parts of the skeleton at the same time. Bone substance, cancellous and laminated alike, is absorbed, and spontaneous fractures occur or deformities of the weight-bearing bones may be observed. Fever may be present and is intermittent. The condition is attended sometimes by pain in the affected structures. The presence of Bence-Jones' bodies has already been referred to. Besides the above, the general changes in the blood are marked and may be simply those of anemia, or even of pernicious anemia.

Chloroma.—This rare tumor is subject to the same observations as myeloma, to which it is closely allied; like myeloma, it is classified by some as a sarcoma; by others, as closely akin to leukemia or pseudoleukemia. The tumors derive their name from the presence of a green pigment in variable quantity, giving the tumor a green or greenish hue. The tumors are rare, and arise usually in connection with the periosteum of the bones of the face and cranium and with the spinal column. In the face they are especially frequent about the orbit. Various organs in the body become affected, as the liver, spleen, thymus, tonsils, lymph-nodes, bones, kidneys, and alimentary tract. The chloromatous tissue increases rapidly in size and there are associated changes in the blood. The blood-pictures resemble those of lymphoid or myeloid leukemia or, rarely, pernicious anemia. The condition occurs in children and young adults and runs a rapidly fatal course of from six to eighteen months' duration.

Endothelioma, Mesothelioma, and Perithelioma.—The tumors of this group arise from the endothelial linings of the vessels and the serous cavities. Their exact place in the classification of tumors is not agreed upon, especially in so far as the mesotheliomata are concerned. The discussion here is based upon the belief that all the forms of endothelial cells concerned are of mesoblastic origin.

Endothelioma.—This tumor arises from the endothelial lining of the blood capillaries or from that of the lymphatics. Hence there are hemangio-endotheliomata and lymphangio-endotheliomata. Section of such tumors shows groups of cells arranged concentrically around the lumina in whorls, and between the various groups lies the stroma with a considerable supply of cells. The central area of the whorls may be loosely filled with endothelial cells, or sometimes the lumen is distinctly patent and shows blood-cells. In other instances the whorls fail to be found or appear only in certain areas of the tumor, and the general appearance becomes more like that of a sarcoma.

These tumors may be single or multiple; they grow slowly, and generally do not infiltrate surrounding structures and rarely become metastatic. They are at times encapsulated, or there may be no distinct line of separation from surrounding tissues. They almost invariably behave as benign tumors.

Hemangio-endotheliomata appear in various structures, such as bones, where they cause absorption and expansion, or in the viscera, but their most frequent site probably is in connection with the dura mater, or less frequently in the choroid plexus. In the two last-named sites they are spoken of as psammomata, owing to the fact that the cells have undergone hyaline degeneration and lime salts have been deposited, which can be recovered from the tumors in the form of small granules, or brain-sand (acervulus), such as is found in and about the pineal gland.

Mesotheliomata.—The word "mesothelium" is employed by pathologists to represent the specialized mesoderm which lines the primitive body cavity, and in the adult stage lines the serous cavities, and the vestiges of cavities which remain from the embryonic period. Hence a mesothelioma may be defined as a tumor originating from mesothelial rests. Many of the tumors which have caused so much confusion on account of their transitional nature are of such origin. They may be of a distinct adenomatous type and behave in accordance with this interpretation, growing slowly and causing no evidence of metastasis or lymphatic invasion. In a lower form they are more like alveolar sarcoma or even round- or spindle-celled sarcoma with no alveolar arrangement. The sarcomatous or malignant type behaves similarly to sarcomata in growth and metastases, and in its fatal termination. Usually

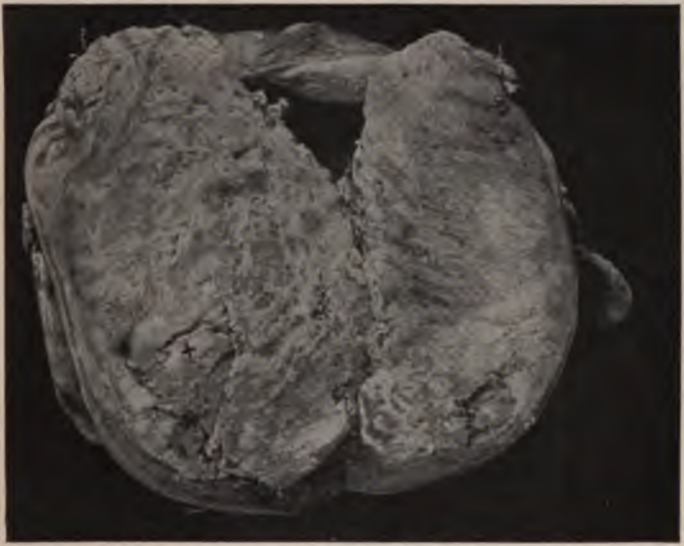


Fig. 172.—Perithelioma of uterus. The tumor mass is very soft and broken down at (x).

the steps of retrogression can be traced in these tumors from the simpler benign stage to the malignant (Adami).

The serous surfaces of the body may be the site of origin of mesotheliomata. This is true both of the peritoneum and the pleura, especially the latter. They are supplied with a moderate stroma of connective tissue and the cells are epithelioid in appearance and arranged in the form of a lining to the acini of the tumor. These tumors are flat and nodular and produce a marked thickening of the membrane, which may be mistaken for an inflammatory product. The structure resembles that of carcinoma very closely, and is classed as such by those who consider these membranes to be of hypoblastic origin. They form metastases in a considerable percentage of the cases, and those arising from the pleura produce sometimes large tumors whose nodules may invade the lung substance.

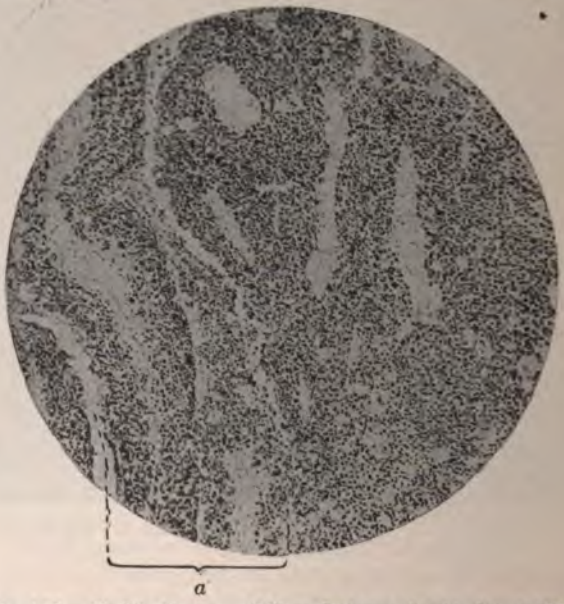


Fig. 173.—Perithelioma. (Microphotograph; × about 100.)

Perithelioma.—The last of this group of interesting growths is the perithelioma, which is supposed to originate in the endothelial lining of the perivascular spaces. They are arranged as cylinders of cells which multiply around the central capillary, whose proper endothelium remains unchanged. The cells lie in rows which radiate from the capillaries. When the older, outer cells of these growths undergo hyaline degeneration the tumor becomes a cylindroma, which is characterized by the presence of capillaries surrounded by several layers of cells and around these the hyaline cylinders.

CHAPTER XLIV

BENIGN EPIBLASTIC AND HYPOBLASTIC TUMORS, PAPILLOMATA

Definition.—A papilloma is a tumor whose essential structure is epithelial (epi- or hypoblastic) tissue resting upon and supported by a connective-tissue framework. The framework here, as in tumors generally, is incidental, and develops secondarily as the support of the tumor-cells may demand.

Classification.—The subdivisions of papillomata are *warts*, *pointed condylomata* (*venereal warts*), *cutaneous horns*, *soft papillomata*, and *intracystic papillomata*. It is not within the scope of this book to discuss molluscum contagiosum, bilharziasis, and coccidiasis, all of which may produce epithelial proliferation somewhat resembling papillomata. Indeed, it is necessary to admit that warts, venereal warts, and cutaneous horns are included under the heading of papillomata only in accordance with long usage, rather than from a feeling that such a disposition can be justified in a pathologic way.

Warts (Verruca Vulgaris).—These so-called tumors are very common, especially on the hands of the young, although they are by no means infrequent in the adult. In the old they are often seen on the scalp. They are often spoken of as hard warts to distinguish them from the true blastomatous papillomata arising from the mucous membrane. Warts arise from the papillæ of the skin, whose epidermal covering becomes thickened and hard. The relation of the papillæ is not lost, although many of them may be involved in the structure of a single wart. They are benign, slowly growing elevations, sessile or pedunculated, painless except in consequence of irritation, and usually of small size, rarely becoming as large as a bird's egg. They are often multiple, so that occasionally a child's hands may be almost covered with them. Warts are thought to be due to some kind of irritation, a belief long held by the laity and vulgarly attributed to playing with frogs. They may occasionally, it is said, be transmitted from one individual to another by contact. The harder, larger, rougher examples are fissured and uneven, and the various papillary columns may be separated from each other. These, vulgarly known as "seed-warts," are much more likely to be painful and frequently bleed. Warts often come and go without discoverable cause, so that whole groups of them disappear in a short while, a fact that renders them especially amenable to the conjurer's art. On the other hand, they may persist indefinitely, especially the larger, hard kind.

Treatment.—Warts may be removed by the application of nitric acid, chromic acid, glacial acetic or trichloracetic acid, by the galvanic needle, the actual cautery, excision, by cutting them flush with the skin and cauterizing the base, or by freezing with CO_2 snow. Liquid escharotics should be employed sparingly, and applied with utmost precaution to warts situated in close proximity to the nails, as the fluid will encircle the nail and cause considerable damage.

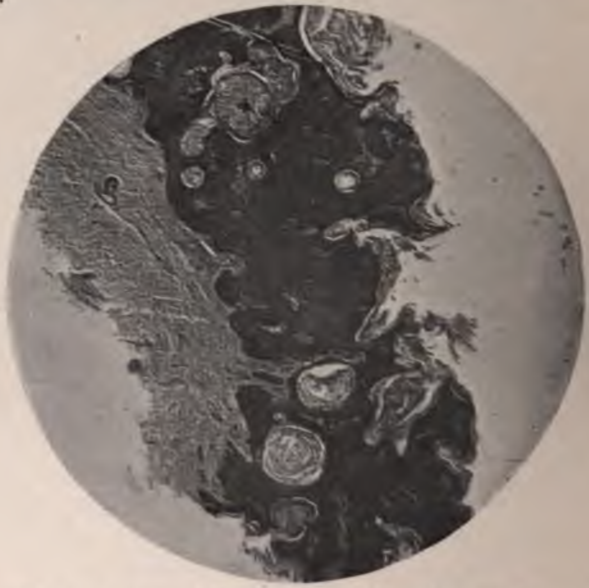


Fig. 174.—Wart, showing epithelial pearls. (Microphotograph; × about 10.)

Pointed Condylomata.—Venereal warts, as they are commonly called, arise in the region of the anus, perineum, vulva, vagina, prepuce, and glans penis, always in consequence of moisture, filth, or foul discharges, such as occur in connection with venereal diseases, especially gonorrhea and chancroids. It must not be assumed, however, that the presence of venereal warts is a proof of such a disease. They are rarely encountered in the mouth. They may be small, single, and resemble ordinary warts. They are often multiple, and if the causative irritation and moisture continue to stimulate them they may attain such enormous size as to render delivery of a baby impossible; or on the penis, cover the glans entirely and give it a most bizarre appearance. When these tumors reach a considerable size they are nodulated and of uneven surface, resembling a cauliflower. These growths, if allowed to remain indefinitely, may become epitheliomatous.

Treatment.—They usually disappear spontaneously when the discharge is controlled and they can be kept dry, or, at any rate, cease to grow under such circumstances. If they cannot be relieved in this way, they may be excised as by circumcision when they are on the prepuce. Otherwise they are to be dealt with as warts. The continued application of oleum ricini often entirely relieves them.

Cutaneous Horns (Cornu Cutaneum).—This rare and remarkable condition is seen usually in the old. It is due to the excessive development of the keratinous layer of the skin and a failure of exfoliation. These growths spring from the skin, which does not become attached to the underlying structures, remaining movable. The horns are extremely hard at their surface and internally are filled with a friable substance. They arise from scars or healthy skin or may be associated with cancer. The surface of these growths may be smooth or rough and warty. They are usually single, but may be multiple, and are more common in women. Their size is occasionally astonishing, specimens reaching occasionally a length of 10 to 12 inches and 1 inch or more in thickness at their base. They may grow in curved, spiral, or irregular shape. They are usually seen on the face, scalp, back of the hands, less frequently on the penis, scrotum, trunk, and extremities.

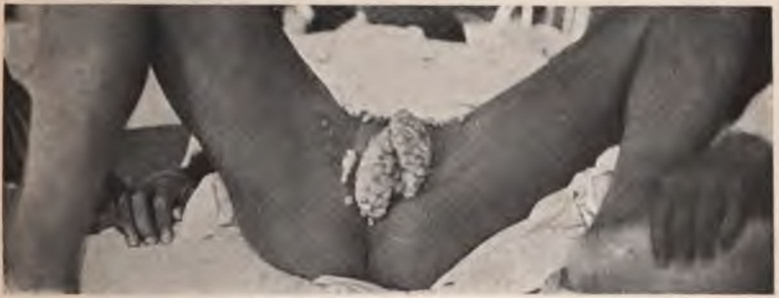


Fig. 175.—Venereal warts.

Treatment.—Removal. They sometimes drop away without treatment, especially if injury or infection has been incurred.

Soft Papillomata.—These growths, together with the intracystic papillomata, belong properly to the tumor group. They arise from the mucous membrane and grow by predilection from the bladder, the uterus, and the renal pelves, from the alimentary tract, the upper air-passages, and rarely in the ventricles of the brain. The tumors are sessile or pedunculated nodules or may grow into long, thin, branching processes. The villi may be densely packed in tufts or may be less closely placed, giving a velvety feel.

Unless they occur in accessible portions of the mucous membranes they cannot be diagnosed until the time of operation. They may be first suggested by the occurrence of hemorrhage, and this is quite common in papillomata of the urinary bladder, where they frequently attain a considerable size and are prone to become cancerous, some authors maintaining that they should in this particular organ be acted upon as if they were already malignant by removing a segment of the bladder wall. The same may be said of those occurring in the renal pelves. The villi are occasionally broken away from the tumor and pass from kidney into bladder and are voided with the urine. The hemorrhage ensuing upon such an accident occasionally endangers life. The passage of villi through the ureters may produce renal colic; when papillomata occur in the renal pelvis they are often bilateral, and the bladder may be affected in such manner as to suggest that the tumors have become transplanted from the kidney to its mucous membrane.

Treatment.—The treatment of soft papillomata should consist in thorough removal of the tumor and its base, and if the growth is extensive the organ affected or that portion of it involved may require to be removed.

Intracystic Papillomata.—This growth is a papillary tumor which forms from the lining surfaces of cystadenomata. They are seen most frequently in adenomatous cysts of the ovary or the mammary gland. They may also be found in the liver and the kidneys.

Intracystic ovarian papillomata grow in the shape of warts, as cauliflower or arborescent figures, or may be nodular. They are reddish or white in color. They rarely arise from the outer surface of the cyst wall. The tumors are bilateral in more than half the cases and often attain large dimensions. They frequently cause a rupture of the cyst wall and grow through the rent into the general peritoneal cavity. The tumors often become cancerous.

Treatment.—Removal of the cyst or organ in which the tumors arise.

CHAPTER XLV

ADENOMA

An adenoma is an epithelial tumor whose essential structure is glandular tissue. The cells of the tumor imitate the arrangement habitually assumed by the cells of the structure from which the tumor rests originated. Hence it is usually easy to recognize the nature and origin of adenomata even when heteroplastic or metastatic. There can, for this reason, be no single type toward which glandular tumors tend to conform; they must rather be interpreted in their relationship to the various glands of the body.

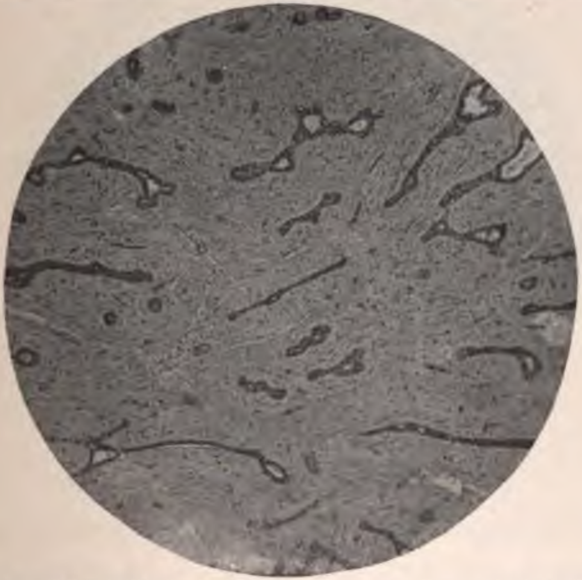


Fig. 176.—Adenofibroma of breast. (Microphotograph; × about 50.)

In a general way they may be subdivided into solid adenomata and cystic adenomata; the latter resulting from the accident of attempted function in certain of the glandular tumors. The cells, too, vary as much as the cell arrangement, resembling the respective cells from which they originate, and these cells may secrete a fluid somewhat resembling the normal secretion of the type, the accumulation of which is responsible for the cystic adenomata.

Structure.—Glandular tumors primarily are encapsulated growths. There is a systematic arrangement of the acini and ducts of normal glandular tissue such that the products of glandular secretion are conveyed into proper outlets, and in the ductless glands the secretions escape into blood- or lymph-channels. There is no such arrangement, as a rule, in tumors, even when they arise in the midst of the most active glands. The whole of the tumor—cells, ducts, and secretion, if any is present—is enclosed within the capsule, and hence could be of no service to the body even if the secretion were normal. Certain adenomata maintain a duct connection similar to that of the glands from which they spring. But the line of differentiation between hypertrophy of adenoid structures and adenomata is poorly established, and while the behavior of the two types is very similar, pathologists are divided concerning the identity of the two conditions. Examples of adenomata emptying themselves normally are seen most frequently in polypoid adenomata of the alimentary canal, in those of the upper air-passages, and in adenomatous prostatic hypertrophy. The relation of the epiblastic and hypoblastic cells to the limiting walls of connective tissue or basement-membranes is the same as in normal glands, namely, they lie within the acini and tubules, and form a lining to those spaces. This lining varies in thickness, so that the whole space may be filled with cells lying layer upon layer, or if there be a secretion present the center of the space will be distended with fluid, resulting in a

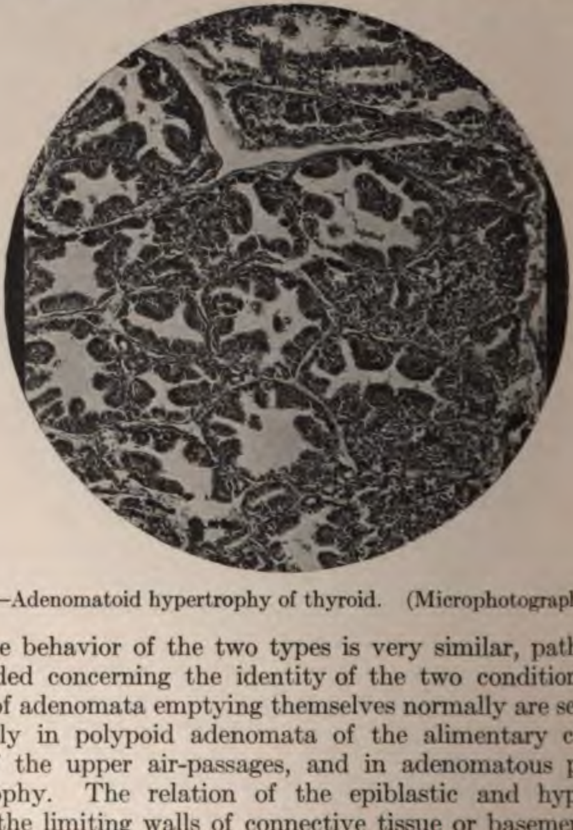


Fig. 177.—Adenomatoid hypertrophy of thyroid. (Microphotograph; × 75.)

cystadenoma. The cyst in these cases may be simple or multilocular, dependent upon the number of the pockets of fluid accumulated. The blood-supply is conveyed along the supporting connective-tissue framework.

Sites of Formation.—It has been stated already that adenomata may arise in connection with or in proximity to glandular structures, wherever situated. They are, as one might surmise, of far greater frequency in certain glands.

Mammary Gland.—The majority of benign tumors arising in the breast are adenomata. The pure form of mammary adenoma is comparatively rare. These tumors are small and rarely reach a size larger than that of a walnut unless they have become cystic. Several small adenomata apparently independent of each other and of widely varying size are sometimes seen bound together into a single mass by connective tissue. Adenomata of the breast are reddish-gray or white in color, and are definitely delimited from the surrounding structures. The reddish tumors somewhat resemble the pancreas in gross appearance. The usual benign tumor of the breast is the fibro-adenoma or adenofibroma, as it is generally called. The former name is probably more correct. Adenomyxoma and adenosarcoma are closely allied growths, if we consider the adenomatous tissue as the more important from an etiologic point of view. Fibro-adenoma is rather frequent; some

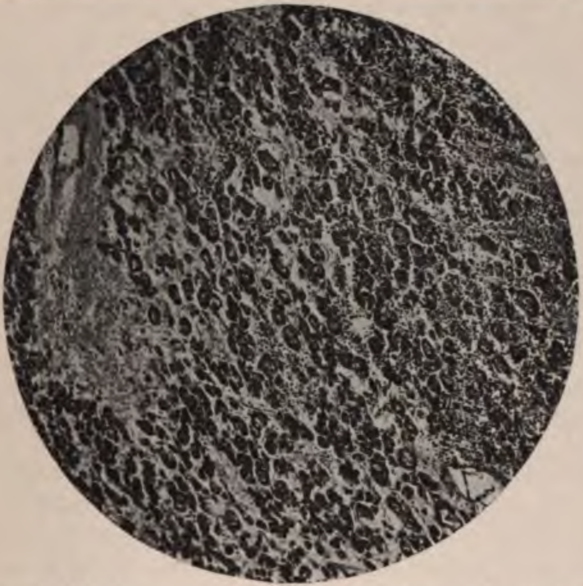


Fig. 178.—Fetal adenoma of thyroid. (Microphotograph; × about 100.)

authors have doubted the existence of pure fibroma, and others the existence of pure adenoma of the breast, thinking that in a supposed case of either a continued search would reveal the presence of the other type of tissue. Fibro-adenoma and adenofibroma are employed in naming these tumors respectively according to the predominance of glandular or fibrous tissue. They are irregular, nodular growths, which occur most frequently in women past thirty years of age, although they are sometimes found in younger women, even as early as puberty. They may be single or multiple, are thoroughly encapsulated, and do not become large, rarely attaining the size of a golf-ball. They are firm and usually very movable. These tumors are occasionally painful.

Salivary Glands.—In any of the salivary glands adenomata may appear, but, as in the case of other tumors affecting these structures, with far greater frequency in the parotid. They occur rarely even in the parotid. The pure form of adenoma occurs as a small, slowly growing tumor, which is not very movable. They are soft and more or less nodular and may become cystic.

In the mixed form these tumors appear in the parotid gland as adenochondroma, adenofibroma, cystadenoma, adenocarcinoma, and adenosarcoma. Rarely adenomata of the salivary glands which were structurally benign have gained entrance to the blood-vessels and been distributed throughout the body, producing unquestionable metastases.

Thyroid.—Single or multiple adenomata may develop in the thyroid, and appear either as congenital or postnatal tumors, thus constituting one form of goiter. They are slowly growing, movable, benign tumors, and the individual growths may attain the size of a fist. They, too, just as adenomata of the salivary glands, may become metastatic, preferring the osseous system, although their remaining characteristics are those of benign growths. Adenoma of the thyroid may become cystic, and this form has been observed occasionally to result in large cysts of the gland which were ensheathed in a thick capsule which contains a greater or smaller deposit of lime salts.

Kidneys.—True adenomata of the kidneys usually appear in the old. They are small round tumors and rarely grow larger than a guinea-hen's egg. They are usually solitary and yellowish-brown or white in color. They may occasionally be multiple. There is, besides the simple adenoma, a papillary type. The two are often mixed. In the adenomatous type papillary elevations arise from the inner surface of the tubules and constitute a tumor within their lumina. This type frequently bleeds. Adenomata usually appear in the cortex.

Alimentary Tract.—The mucous membrane of the stomach may be the site of adenomata, which develop as either adenomatous polypi or broad, flat tumors. They are usually small, but may develop into larger tumor masses, and are single or multiple. Kaufmann subdivides them into *simple, cystic,* or *papillary;* in the latter they assume an elongated form, resembling papillomata of the mucous membrane. These adenomata are made up of the glands of the mucous lining, overgrown and densely packed into the tumor mass. Gastric adenomata are capable of becoming cancerous or may appear conjointly with cancer of the stomach.

In the intestine the same forms of adenoma may appear as in the stomach. They occasionally reach the size of an apple, but are usually small and multiple; the tumor may cause intestinal obstruction by blockage of the lumen or become the caput of an intussusception, or, if situated lower down in the large bowel, cause prolapsus. In the rectum even of children these tumors may appear sessile or pedunculated, and, if the latter, may protrude through the anus and become gangrenous. Hemorrhage from rectal adenomata is not infrequent, and they are unfortunately disposed to become malignant in addition to the harm they do in consequence of their situation. In rare cases a condition known as adenomatous polyposis of the intestines appears, and is so universal in distribution that the whole alimentary mucosa from stomach to anus is lined with tumors. This condition in children may be causative of colic, diarrhea, and melena.

Uterus.—Adenomata of the mucosa of the uterus can be classed with benign tumors only with serious question, and only with the understanding that such classification shall not obscure the fact that, while they may be structurally benign, they are certain ultimately to become malignant, and must be dealt with accordingly. Certain authors, indeed, contend that there is no such thing as a benign uterine adenoma. In the uterus they may appear as adenomatous polypi which arise either in the body of the uterus or in the cervical canal; these are seldom malignant. On the other hand, the diffuse adenoma is the type that deserves to be dealt with only as malignant tumors, for while one portion may show a true adenomatous structure under the microscope, it is probable that some other portion would reveal unquestioned malignity, and it is certain that if left it will do so.

Ovaries.—One of the very frequent sites of adenomata is the ovaries, a fact which is usually lost sight of, owing to the fact that these tumors are cystic, or cystadenomata. Solid adenomata of the ovaries are very rare, but the cystic type is extremely common, and appears as single or multiple, as unilateral or bilateral growths. They may attain an enormous size, specimens having been removed which weighed 100 pounds or more, and cysts containing several gallons of fluid are frequently seen. They are unilocular or multilocular, and while usually of the simple cystadenomatous type, may contain intracystic papillomata (*q. v.*), cystadenoma papilliferum. The consistency and fluctuation of cystadenomata depends on the amount of solid tissue present, especially of that constituting the cyst-walls and separating the pockets. The papilliferous cysts grow more slowly and attain a much smaller size than the simple form.

Liver.—Two types of adenoma appear in the liver either independently or both in the same tumor mass. One of these types is made up of liver cells and shows an imperfect and irregular formation of acini; while the second, made up of epithelium which lines the bile channels, appears to be formed by the development of numerous closely placed bile channels. Adenoma of the liver may be single or multiple and does not ordinarily attain large dimensions. They are usually well defined and encapsulated, showing a definite termination at the border, and compressing the surrounding liver structure, a phenomenon which does not appear in hyperplasia. The cellular adenoma is a soft, whitish, yellowish-brown, or reddish tumor whose cells may produce bile, and the channel or duct adenomata are often converted into cystadenoma by distention with fluid. Adenomata are especially apt to develop in cirrhotic livers where hyperplasia also is especially well marked, and in these cases the two conditions can often not be differentiated from each other. Either form may undergo malignant change.

Other organs are occasionally the site of development of adenomata, namely, the testicle, the pancreas, and the prostate. However, the enlarged prostate usually encountered is due to hypertrophy rather than to tumor formation.

Symptoms.—Adenomata have usually all the characteristics of benign tumors. They grow slowly as round, encapsulated, movable tumors, and are found in glands in close proximity to them, or in structures, such as the mucous membrane, which normally contain glandular tissue. They are rarely heteroplastic. More rarely adenomata develop in the form of pedunculated polypi attached by their pedicles to the mucous membrane, or as broad, flattened growths such as are seen occasionally in the endometrium. Adenomata develop usually prior to middle life, are of only moderate dimensions, and do not, therefore, produce symptoms by their mechanical presence. Exceptions to this statement are to be found in the intestinal tumors, which serve as a starting-point for intussusception or produce intestinal obstruction by blocking the lumen of the gut, where they develop in the rectum and narrow its dimensions, where, by their great number in the alimentary tract, they cause diarrhea and melena, and when occurring in the uterus they produce an abnormal menstrual flow, just as a beginning cancer might. Adenoma is the only benign tumor other than chondroma which has been observed to produce metastasis.

Variations.—Adenoma is frequently combined with other tumor elements. Fibro-adenoma, adenosarcoma, and adenocarcinoma are the more important forms.

Pathologic Changes.—The most important fact to be impressed in connection with adenoma is that it is under certain circumstances liable to become carcinomatous, and in the uterus particularly should be regarded as if it were indeed already malignant. Those who are accustomed to have microscopic examinations made of tumors of the breast which have been removed early know how often microscopic evidence of cancerous transformation is found in mammary adenoma. This further statement is also important, namely, that while certain portions of an adenoma are unquestionably benign, no conclusion can be drawn therefrom that no other portion of the tumor is malignant.

The other important change ensuing in adenoma is the conversion of the tumor into a cystadenoma. This may follow in any case where a secretion is produced and no outlet for it is provided; but, as a rule, the cysts, like the adenomata, are small. The case is very different in the ovary, in which enormous cysts, already referred to, form with very great frequency. Moderately large cysts are produced sometimes in connection with adenomata of the thyroid.

Prognosis.—So long as adenomata remain benign they do not endanger life, and because of their small size cause little or no deformity. The possibility of malignancy developing in any tumor of this type introduces an element of uncertainty so long as the tumor remains; in the mammary gland it is fairly probable that such a tumor is beginning to show malignant cells or that it at any time may do so. In the uterus it may be accepted as the best guide that it positively will become malignant unless it is the polypoid variety, and even then it may. The cystic tumors arising from ovary or thyroid especially demand interference, owing to the distress, danger, and deformity produced by them. These cystic tumors rarely become malignant.

Treatment.—Usually an adenoma may be removed by enucleation, but whether the work shall rest here should be determined by the microscope. The finding of malignant cells calls for more radical work. Organs of vital importance, such as the kidneys, should not be excised for adenomata, for the growths are often bilateral; it is, therefore, better to enucleate. When the malignant form appears in the uterus no other treatment but hysterectomy should be done.

CHAPTER XLVI

CANCER

The term "cancer" is employed here to embrace all forms of malignant epiblastic and hypoblastic tumors. Those tumors of malignant or semimalignant nature arising from the endothelium, according to most teachers, namely, endothelioma, mesothelioma, perithelioma, and cylindroma, have been discussed already in connection with sarcoma. Ribbert and others, however, claim, with weighty evidence sustaining their views, that they should be classified with cancers.

Definition.—A cancer is a malignant epiblastic or hypoblastic tumor.

Classification.—From a practical standpoint it is customary to subdivide cancer into epithelioma and carcinoma. The former is derived from squamous epithelium or by metaplasia from the other varieties, and the latter from the glandular and other epithelial cells not of the squamous type. Carcinomata, therefore, originate from those structures which contain glands or gland-ducts, and arise in organs containing the non-squamous cells. In a word, epithelioma arises from non-functionating, while carcinoma arises from the functionating, epiblastic and hypoblastic cells, a fact that reminds one strikingly of the relationship sustained by hard warts and adenomata to the same cell types respectively.

Clinical Classification.—

1. Epithelioma.
2. Carcinoma
    - (*a*) Soft, medullary, encephaloid, or acute.
    - (*b*) Hard, scirrhous, or chronic.

Ribbert's Classification.—

1. Squamous-celled cancer, distinguished by the presence of cornifying epithelium.
2. Glandular skin-cancer, which does not show cornifying cells and is related to the skin glands (cylindroma).
3. Cylinder-cell cancer, in which the epithelioma is arranged in the shape of glandular ducts.
4. Glandular cancer, which originates from the glandular (functionating) epithelium.

Some of the classifications give also a colloid type of carcinoma which really appears, but the colloid condition is incidental, hence it is omitted here.

Etiology.—The subject of the causation of cancer has been most exhaustively and, one might add, fruitlessly studied during the last decade. We are to-day where we were at the beginning, in total ignorance except in so far as most men believe that failure along certain lines has convinced us that the cause lies not there.

When the real relation of bacteria to so many diseases was established and their possible etiologic relation was suspected or accepted in many others, hope was widely stimulated that the cause of cancer might be sought and found in the form of an extraneous parasite. Various, numerous claims have been made, only to be overthrown; and although the work still continues in a few laboratories, the search for a bacterial cause has resulted largely only in the conviction of the majority of the profession that cancer is not of parasitic origin. There is much other evidence that it is not produced in this way, as a close study of the origin, growth, and behavior of cancer cells will show.

The view most widely held and supported by the most accurate pathologic work is that cancers originate similarly to other tumors, namely, from pre-existing cells of the body. In these pre-existing cells there must be an innate capacity to multiply rapidly and indefinitely (hence the greater tendency of embryonic analgen to produce cancers), a stimulant to excite this innate tendency to action, and such conditions present as will favor their growth in a typic malignant fashion, namely, to infiltrate tissues whose normal function embraces the restriction of those very cells to a definite position in the body. It is thought that cells which are not embryonic may be caused to develop into cancer, but universally admitted that the embryonic cells show much greater adaptability for the necessary requirements.

Ribbert's view of the origin of cancer, based upon an exhaustive study of beginning tumors ("Karzinom des Menschen"), is that the tendency to indefinite proliferation must be present in the epiblastic or hypoblastic cells from which the tumor arises, that a stimulus must call forth their multiplication, and that the limiting basement-membrane must be acted upon in such a way as to admit the growth of the epithelial cells through it into the tissues. These two conditions he finds in the action of slow irritants which produce a mild, chronic, not necessarily infective, inflammation, caused often by the failure of the tegumentary cells to throw off their secretions normally. This irritation stimulates the epithelial cells to a greater activity and destroys or damages the basement-membrane to such an extent that it can no longer resist the inward growth of cells, which, if the connective-tissue substratum remained intact, could only heap themselves up into a non-malignant growth. This inflammatory process Ribbert finds constantly present in

beginning cancers, the majority of those studied being naturally skin-cancers, owing to the impossibility of obtaining beginning cancers of the deeper structures.

What is known definitely and positively accepted concerning the etiology of cancer? First, that chronic irritation is unmistakably and often a predisposing cause; second, that it is prone to arise in connection with certain pathologic conditions, which in their turn may be caused by, or be the source of, or render the part more susceptible to, irritation.

While trauma plays an important part in the history of sarcoma, irritation, prolonged, repeated, or continuous, sustains unquestionably an equally definite relation to cancer, which proves beyond a doubt that even if embryonic vestiges or normal adult cells are capable of producing cancer, they may never harm their host unless irritated into activity. There are numerous illustrations of the sequence of cancer upon an irritant, more numerous, naturally, among those found on the surface and at the apertures of the body.

The frequency of cancer of the lower lip in men and its paucity in women is attributed to the fact that men smoke or use tobacco otherwise; and the continued irritation of tobacco, of the pipe-stem, and the heat are responsible for the difference. The lower lip is almost invariably affected, because it is pressed against the pipe-stem in supporting or shifting the pipe.

Cancer of the tongue is often consequent upon irritation caused by improperly kept teeth, the jagged or sharp edges causing a constant irritation of the mucous membrane until a perverted growth of cells is established. It is also more frequent in tobacco chewers. A singular form of cancer resulting from irritation is found in the case of English chimney-sweepers, among whom nearly 50 cases of cancer of the scrotum have been reported. The condition is not found elsewhere. The chronic irritation by soot is assigned as a cause. Other cases of irritation cancer are recorded due to the action of tar and paraffin. Probably an important explanation of the frequency of cancer at the pylorus, the ileocecal region, and the rectum and anus is that these are the points of greatest irritation in the alimentary tract.

One of the most distressing and apparently certain irritative causes of cancer is the prolonged action of *x*-rays. It occurs chiefly among physicians who allow themselves to come within the field. The skin becomes irritated, rough and fissured, and the nails unhealthy; keratosis develops and at variable periods thereafter one or several cancers develop. The cancer often appears long after cessation of causative exposures.

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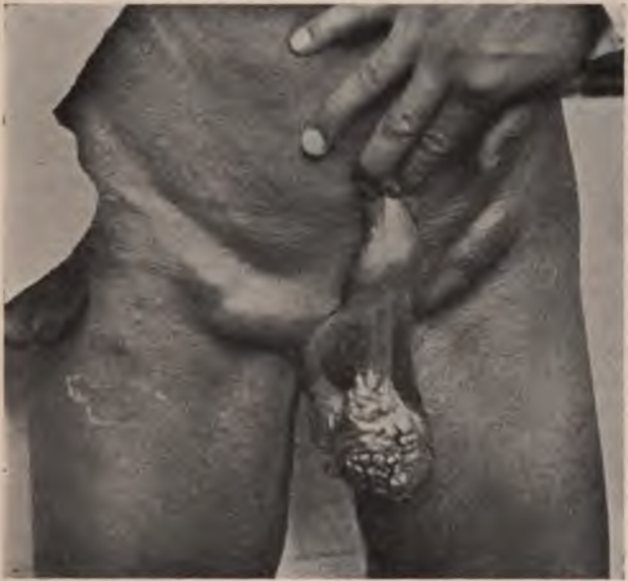

Fig. 179.—Epithelioma of scrotum, showing extensive lymph-node involvement. This patient has worked twenty-two years in a gas factory.

The same factor of irritation favoring the development of cancer is manifested in pathologic processes of various kind. Cancer of the gall-bladder is associated with gall-stones in at least four-fifths of the cases, and probably even in a much higher percentage. The same rule obtains relative to sex in both gall-

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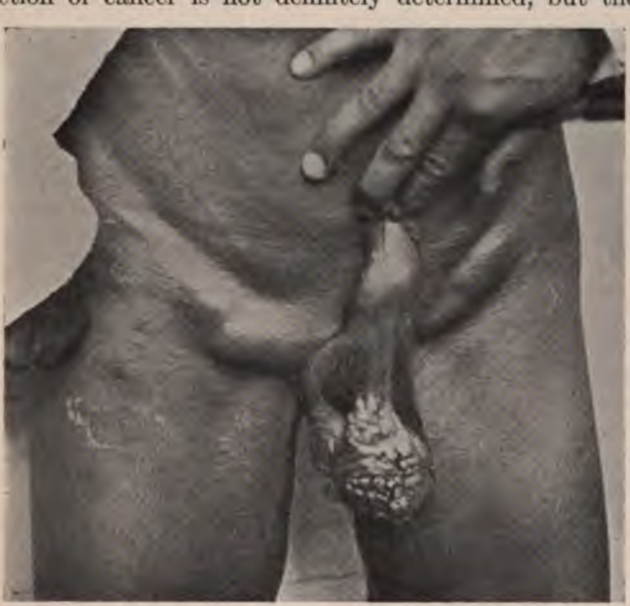

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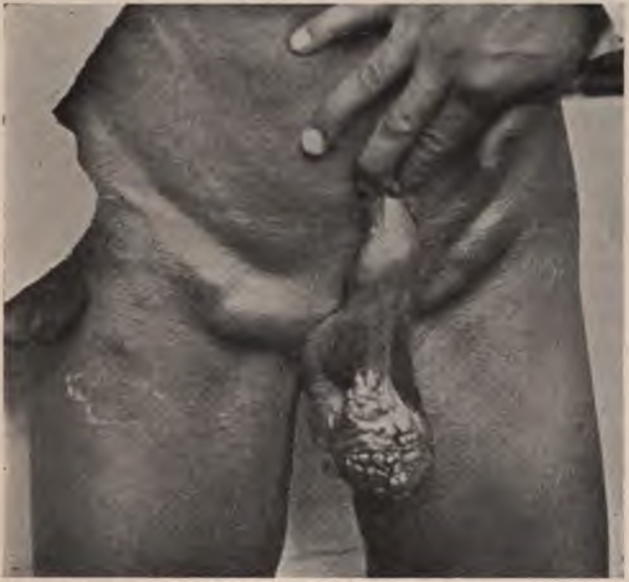

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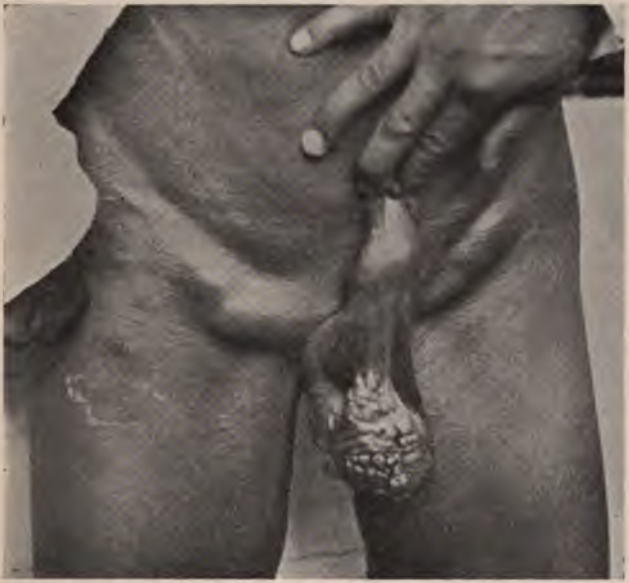

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stones and cancer of the gall-bladder, both being much more common in women. Fütterer found 209 cases of gall-stones reported in 268 cases of cancer and no mention of their presence or absence in the remaining 59 cases. Siegert found 94 cases of gall-stones in 99 cases of gall-bladder cancer. The fact cannot, therefore, be denied that there is a very definite and almost uniform correlation of the two, and this can be explained only on the ground that gall-stones may by their continued presence encourage the development of cancer.

A similar condition is found in the origin of cancer of the stomach in connection with or subsequent to ulcer. Ulcer is accepted at present as the most important predisposing cause of cancer of the stomach. Graham estimates that 61 per cent. of the large number of cases of gastric cancer he has studied were preceded by ulcer. Here the condition is the reverse of that observed above in connection with gall-bladder cancer, namely, that gastric cancer and gastric ulcer are both more common in the male sex.

Similarly, certain inflammatory or allied processes may serve as the starting-point of cancer; examples are abundant. Chronic gastritis is given by Kaufmann as a cause of gastric cancer. Likewise the following cases given by Ribbert illustrate the point: cancer developing in connection with ectopia vesicæ, cancer of the vagina irritated by wearing a pessary, cancer of the breast in which a sewing needle was found, cancer following the application of vesicants to a wound, cancer of the skin following the frequent application of CO_2 ice to lupus erythematodes, carcinoma of the navel due to uncleanliness, carcinoma of the penis when the prepuce is long in contrast with its absence in the circumcised; the greater frequency of carcinoma of the esophagus from the use of tobacco and alcohol, and of the mouth from chewing tobacco or betel nuts (as the Hindoos do).

In leukoplakia buccalis, a condition found in smokers, chewers, and brandy drinkers, cancer develops much more frequently if the patient is syphilitic. So true is this that some authors claim that it occurs only in syphilitics, unquestionably an untenable position. It is attributable to syphilis in about three-fourths of the cases, and to the other causes, especially tobacco, in one-fourth. A similar condition is occasionally observed on the penis and on the vulva (kraurosis). The importance of this lesion lies in the fact that it plays a heavy rôle in the production of cancer of the tongue and mucous membrane of the mouth. Of 100 cases of cancer of the tongue observed by Bottini, all were tobacco chewers.

The appearance of cancer as a sequel to pathologic conditions occurs in seborrhea, eczema, lupus, xeroderma, bilharziasis, and keratosis, especially in the latter condition, which seems to be a fairly common beginning of skin-cancer. It is necessary to mention in this connection that the skin lesions following the prolonged use of arsenic may terminate in cancer.

The origin of cancer from moles, papillomata, adenomata, dermoid cysts, and unobliterated vestigial fetal structures is probably subject to the influence of irritation just the same as in the normal and pathologic structures already discussed, with the additional tendency of the more lowly organized cells constituting them to assume an unnatural growth. That is, the cells of these structures are more embryonic, hence more susceptible, than normal cells.

Structure.—In order to present the structure of cancer in a clear manner it is necessary to preface the discussion of this subject with a few fundamental observations: First, a strict interpretation of the word means that cancer is a malignant tumor made up of masses of epiblastic or hypoblastic cells and of nothing else. Whatever else may be present in a gross specimen of cancer is only accidental or incidental, but it is not cancer, whether it is connective tissue or blood-vessels of new formation or normal. These incidental findings may be the direct outcome of the presence of cancer in the tissues, and are often of great value in conveying information to the pathologist, microscopist, or diagnostician; but it must be emphasized that they are no part of the cancer, but are secondary results. The second item is, that cancer grows directly and continuously from the cancer cell or cells which originated it and only by the multiplication of these cells. There is no accession to its substance, no acceleration of its growth by the change of adjacent cells into cancer cells. It grows as a parasite in the tissues and, indeed, is a parasite so far as its behavior and its local and general attitude toward the tissues and the well-being of the body is concerned. There may be more than one primary cancer, coincident or successive, but they sustain no causative relation to each other, and all the cancer cells which ultimately appear in even the worst cases are the direct progeny of the original group, not cells that have become cancerous under the influence of already present cancer cells. Third, the first step in the growth of cancer recognizable by the microscope is the downward growth of cells into and through the normal limiting connective-tissue membrane. This, Ribbert and others claim, is always antedated by an inflammatory process, which on the one hand has stimulated the activity of the essential cells, and on the other impaired the limiting properties of the basement membrane so that the cells may transgress their limits and become "insane cells." The processes which led up to this point may have been long and tedious, but the condition was not cancerous until the cells gained their way through the subjacent connective tissue. Once this barrier has been passed, the development of a definite cancer occurs.

With the above facts before us, we may proceed to study the structure of cancer. So far as its gross appearance is concerned cancer is the most variable of tumors, and presents for the individual tumor no characteristic size or shape. It may appear distinctly and unquestionably as a tumor, or it may appear so unlike a tumor as to offer little suggestion of its true nature. Ribbert says on this point ("Karzinom des Menschen"): "It forms large, often very extensive tumors, or, on the other hand, not seldom only small ones after long years of duration; it appears in the form of a round or irregular mass, often with prolonged extensions; it spreads in nodular form over the skin or mucous membrane, on which it grows with especial readiness; or it disintegrates prefer-

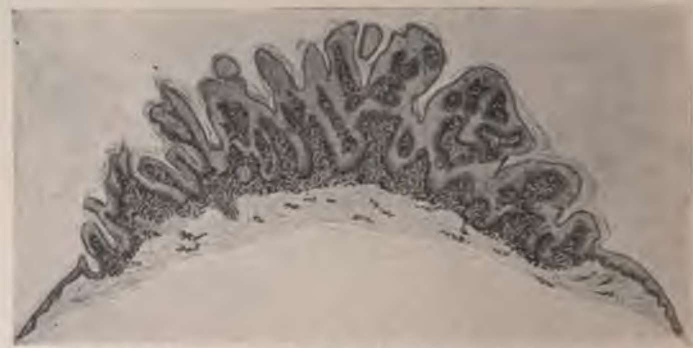

Fig. 180.—Beginning cancer of the lip, showing marked cellular infiltration (Ribbert).

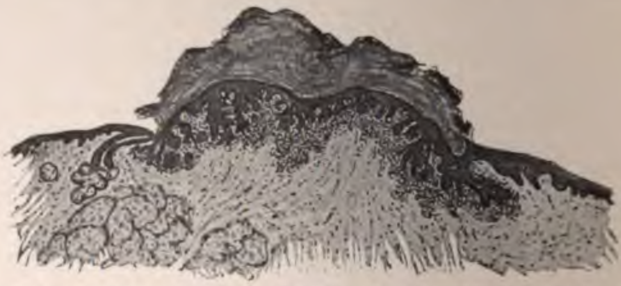

Fig. 181.—Beginning cancer of the lip, showing the epithelial cells lying under a horny mass, and growing into the connective tissue, which shows cellular infiltration (Ribbert).

ably from its free surface to a greater or shallower depth, so that defects exist which resemble ulcers; it has sometimes a soft, sometimes a firm, or, again, a very hard consistence, a grayish-white, marrow-like, or in the hard parts a fibrous cut surface, or it shows a translucent glossy quality. The tendency, when circumstances are favorable, is for cancer to grow in a roundish form, but circumstances interrupt this tendency here more than in any other tumor."

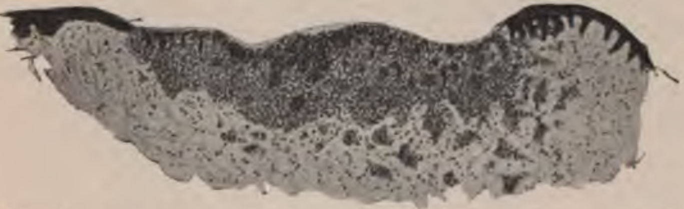

Fig. 182.—Beginning cancer of the lip. Intense cellular infiltration (Ribbert).

Cancer is a non-encapsulated tumor. It may be safely stated that it never is encapsulated and rarely would ever show a suggestion of a pseudocapsule. The only exception to this is to be found in those cases where cancer originates within an already encapsulated tumor and has not yet had time to grow through it. The cut surface of cancer shows on scraping, curetting, or squeez-

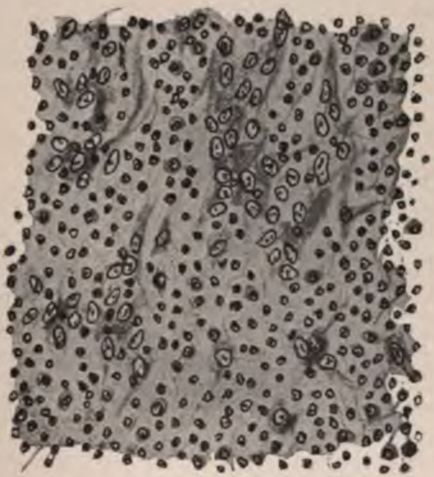

Fig. 183.—Same as Fig. 182. The epithelial cells lie in irregular groups and singly in the infiltrated tissue (Ribbert).

ing a peculiar milkish looking fluid known as cancer juice, which is considered a very important macroscopic characteristic. The tumor shows either a fairly uniform structure, aside from degenerative changes, or bears evidence of harder connective-tissue sections between which lie the more cellular portions. Sections of the tumor or of the tissues adjacent to it by compression yield worm-like strings of cancer tissue if the region is abundantly sup-

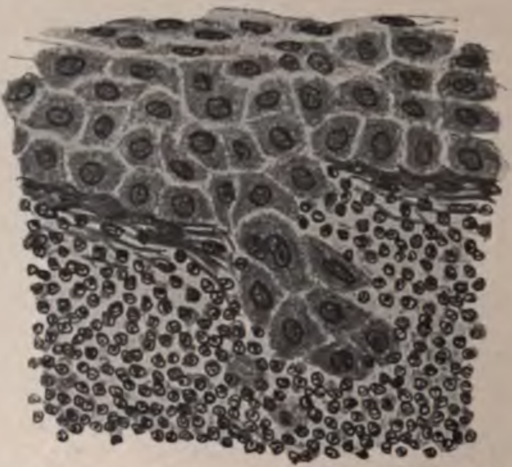

Fig. 184.—The very early stages of beginning cancer of the skin, showing the epithelial cells invading the connective tissue, which is markedly infiltrated (Ribbert).

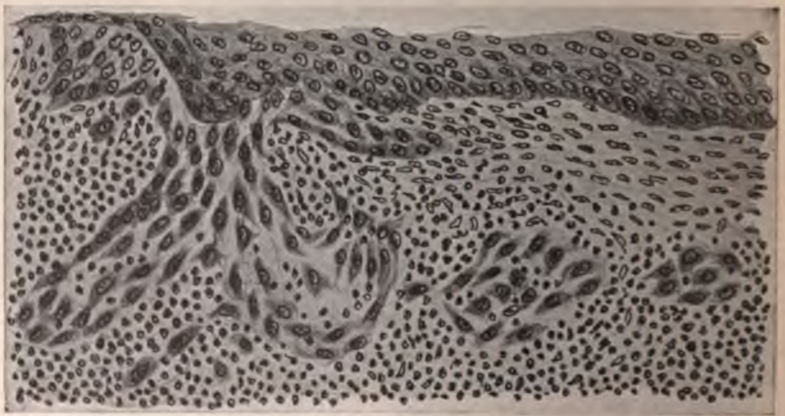

Fig. 185.—Growth of cancer masses of loose-lying cells into the infiltrated connective tissue (Ribbert).

plied with lymphatics, as, for example, the urinary bladder. The blood-vessels of cancer are abundant naturally in the rapidly growing tumors, and in the chronic scirrhous types are very meager. They are more perfectly developed than those of sarcoma. They have no definite arrangement and are thereby unfit to take care of the circulation of the tumor in a normal way, a fact that will need to be borne in mind in the discussion of degeneration of the central older parts of the tumor, while the newer peripheral portions are growing actively.

It has been stated already that cancer is a non-encapsulated tumor. More than this, it shows, when fully developed, more constant clinical evidence of want of capsulation than any other tumor, owing to the fact not only of its immobility, but of the indefiniteness of its outlines; one cannot say just where normal tissue ends and where tumor begins. The same idea is conveyed by examination of gross sections of the tumor together with the surrounding normal tissue; for while the substance of the tumor may abut against normal tissue, the rule is that there is gross evidence of its extension by finger-like processes into the surrounding structures, and these processes gradually become smaller and finally imperceptible.

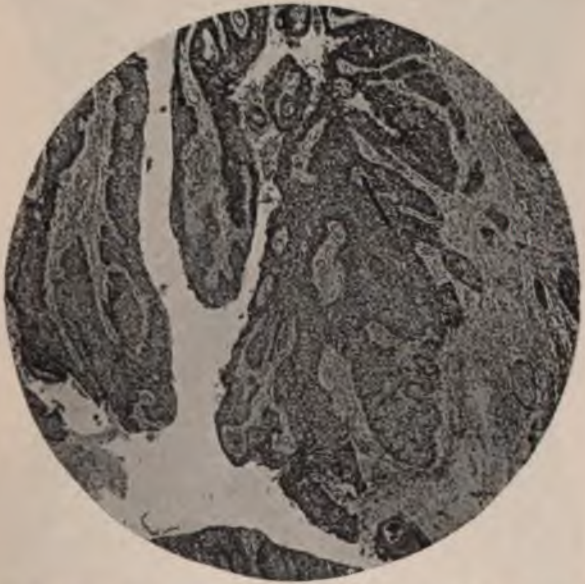

Fig. 186.—Papillary carcinoma of urethra. (Microphotograph; × about 50.)

The minute structure of cancer is very varied and very inter-

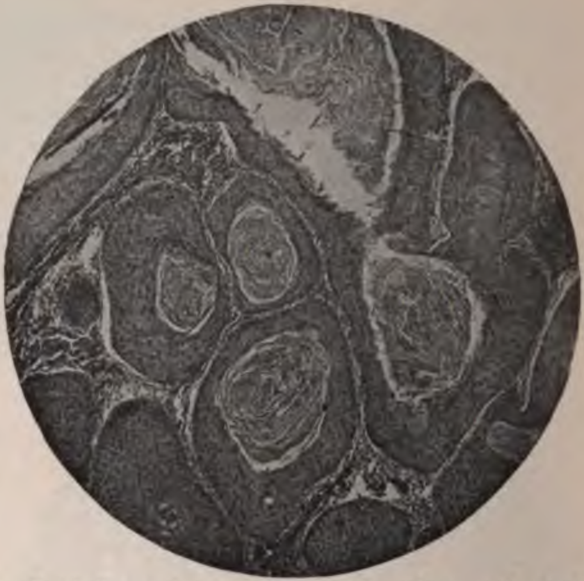

Fig. 187.—Epithelioma, showing pearls. (Microphotograph; × about 5

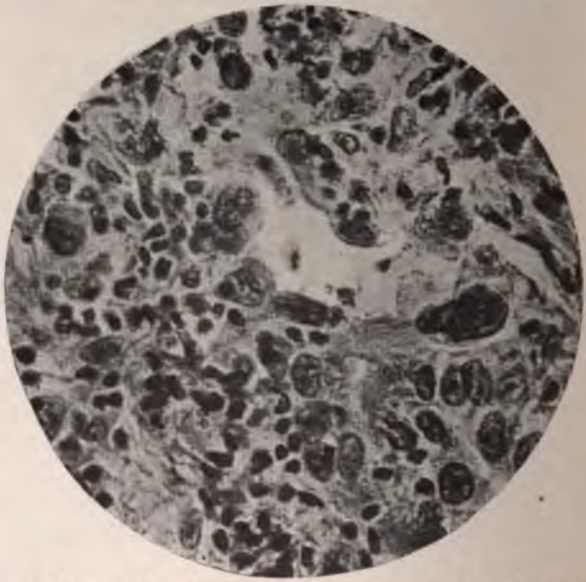

Fig. 188.—Carcinoma, showing large cells. (Microphotograph; × about 2

esting. The only general statement of the facts is covered by s
ing that the epithelial cells of cancer grow without rule or reas

with different arrangement of the cells in accordance with the source or type of cell from which the tumor originated and the accidents of growth. Hence one cancer is made up of cells largely, with relatively little connective tissue, another of connective tissue and a great paucity of cells, with all grades between these two extremes. The arrangement of the cells may be diffuse and in accordance with no plan, similarly to the arrangement usually seen in sarcoma, or into alveoli so far as the microscopic appearance shows; serial sections, however, show that these alveoli are transverse sections of cancer processes which communicate with each other, and altogether go to make a cancer mass through which the connective tissue runs. So that if the connective tissue could be removed it would leave a sponge-like mass of cancer cells. Others are arranged in solid masses of cells which surround lumina representing the tubular glands, for example, those of the skin, to which the anlagen histologically belong. These lumina may appear with fairly uniform distribution or only occasionally, the growth of cells filling in the majority of the lumina. Again, in the duct or cylinder-cell type the same kind of arrangement may be observed,

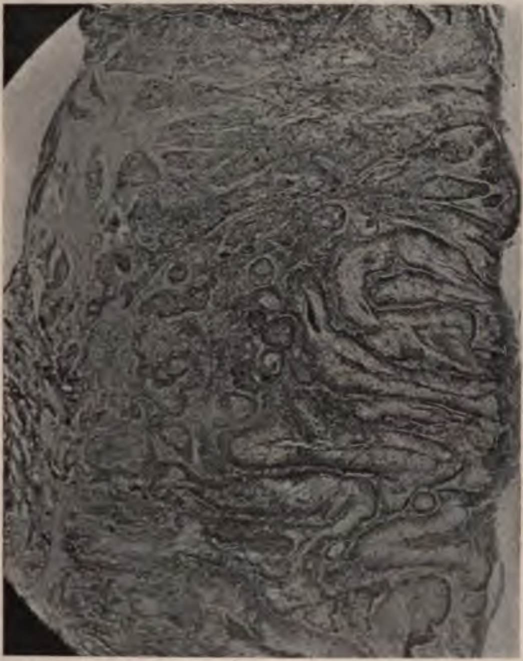

Fig. 189.—Beginning epithelioma of tongue. (Microphotograph; × 12.)

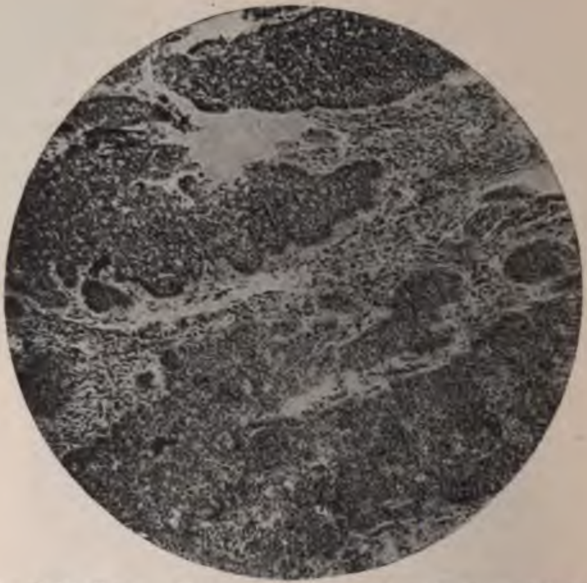

Fig. 190.—Epithelioma. Note arrangement of cells in cylindroid masses. (Microphotograph; × about 75.)

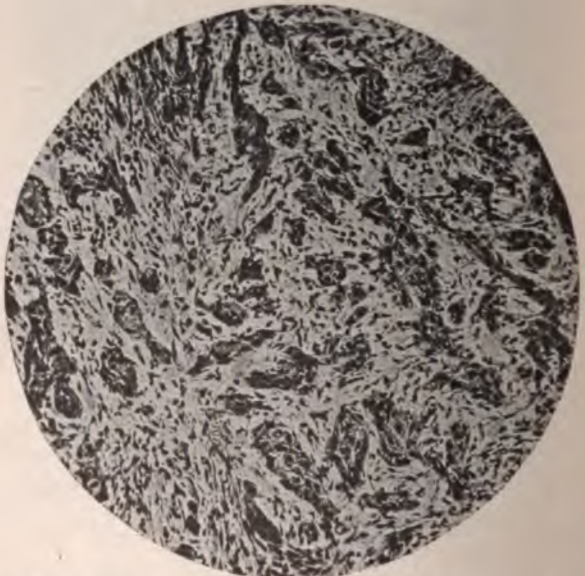

Fig. 191.—Tubular epithelioma of neck. (Microphotograph; × about 1[illegible]0.)

where the typic arrangement is the growth of channels lined with cancer cells, which are usually several layers deep, but may consist of a single layer. Of course, here too the growth of cells may be such as to obliterate the lumen. In the glandular types of cancer the glandular structure is more or less imitated, but marked variations appear even in the same tumor. In the instance of cancer of the breast, for example, the glandular arrangement may be almost perfectly followed, showing distinct lumina; in another the alveoli are filled with cells, although its arrangement would indicate its alveolar character, and yet again the lumen is present and partially or completely traversed by epithelial cell processes growing across it from the alveolar wall. It must not be gathered from the above that cancer of a given structure, even though primary, must conform to the arrangement found there, but to that of the structure to which the cancer cells normally belong; for instance, a carcinoma of the ovary may develop a structure and be of a cell type entirely unlike anything found in the normal ovary. They are supposed to originate from embryomata contained in this organ.

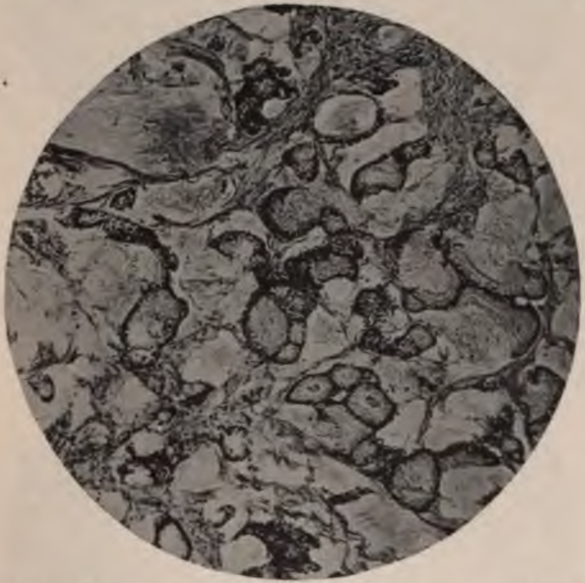

Fig. 192.—Mucous carcinoma. (Microphotograph; × about 100.)

In squamous-celled cancer, or epithelioma, cornification may occur and form concentric rings of horny substance. The so-called cancer perles are formed in this way. The cornifying epi-

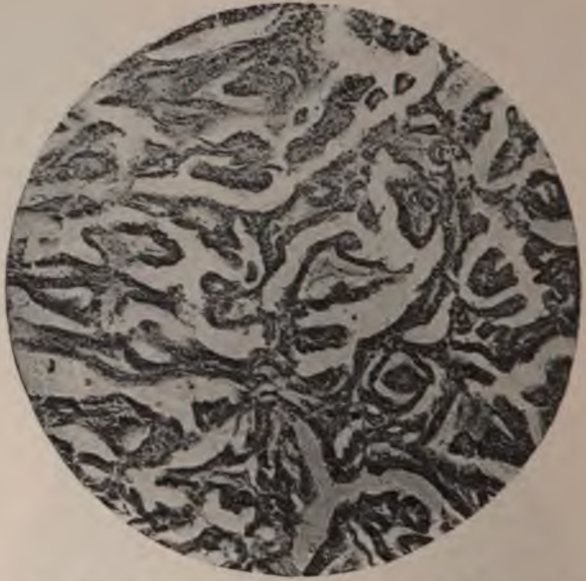

Fig. 193.—Papillary adenocarcinoma. (Microphotograph; × about 100.)

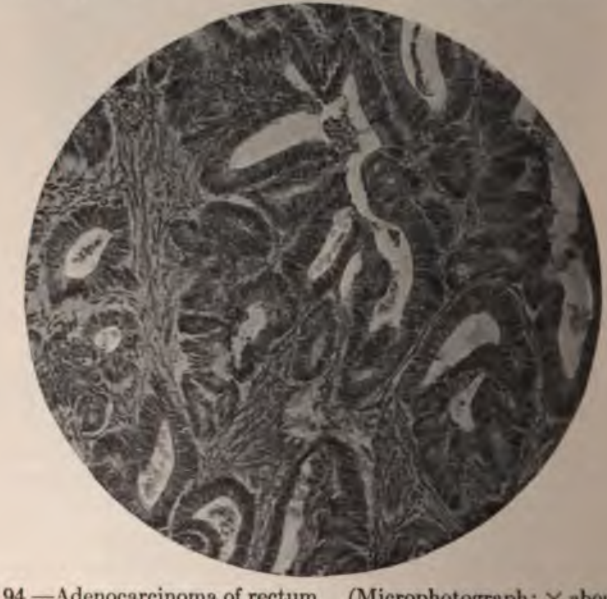

Fig. 194.—Adenocarcinoma of rectum. (Microphotograph; × about 100.)

thelium may be directly continuous with the surface epithelium, or the process may take place in the deeper portions of the cancer and show no connection with the integument. The central, older portions of the masses and processes of epitheliomata undergo this change just the same as the older normal epithelial cells show it. This change is due to the nature of the cells constituting epitheliomata; consequently they do not appear in other forms of cancer.

Colloid cancer, otherwise sometimes mentioned as mucous cancer, is one in which the cancer cells produce a secretion of mucus or a closely allied substance which appears in great or small quantity, and which when abundant necessarily alters the appearance of the cut surface and the clinical signs. It is found by far most frequently in the cylinder-cell cancers, although it is occasionally observed in other forms. They occur with greatest frequency in those structures whose cells normally secrete mucus, especially in the alimentary tract.

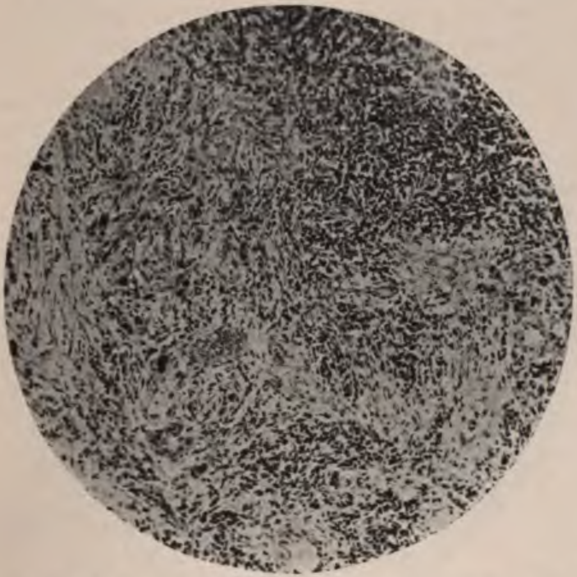

Fig. 195.—Tubular epithelioma of neck. Malignant, showing area of inflammation. (Microphotograph; × about 100.)

Scirrhous cancer is seen especially in the breast, sometimes in the stomach or intestines, and is characterized by a prevalence of connective tissue, sometimes almost to the total exclusion of cancer cells. Instead of the tumor adding to the size of the affected organ, it may, by the contraction of its new formed connective tissue, materially reduce the size of and disfigure the organ. The growth of scirrhus occurs precisely as in the non-scirrhous types of cancer, namely, by multiplication of cancer cells, but the contraction of the abundantly forming connective tissue destroys them, and they so completely disappear that they may not be found except in comparatively widely separated areas. The formation of connective tissue may be so abundant as to form a dense, hard mass, bearing no propotionate relation to the time it has existed. Naturally the older, central portions of the tumor are harder than the recent cellular peripheral part. An important characteristic is the presence of elastic connective tissue in scirrhus of the breast. It is important to know in this connection that scirrhous cancer may be accompanied by secondary cancerous lymph-nodes which show little or no evidence of excessive connective tissue.

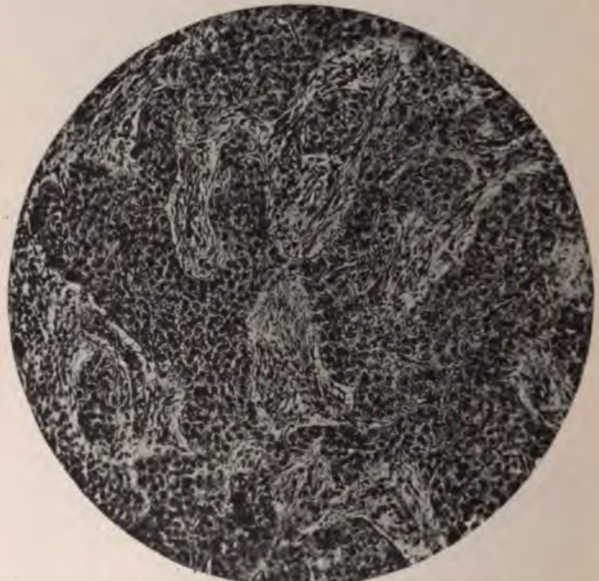

Fig. 196.—Epithelioma of scalp. (Microphotograph; × about 100.)

Giant cells may form from the mixed connective-tissue cells in cases of epithelioma in the same manner as in the case of foreign substances in the tissues. Also in carcinomata of very rapid growth it may happen that very large multinucleated epithelial cells appear, but they are not true giant cells. Still another type of giant cells is seen, and in rare cancerous tumors they are so abundant as to distinguish the tumor from the usual types. The arrangement of the cells, their appearance, and the tendency to hemorrhage has led to the conclusion that they belong to the syncytial type.

The greater the deviation of the cells of a given tumor from the conduct of normal cells, the greater the malignancy of the tumor.

The Growth of Cancer.—It has already been stated that cancer grows only by the multiplication of cancer cells, that the cells of adjacent tissues do not become cancerous, and that it is devoid of a capsule; furthermore, it starts from cells which lie on the histologically proper surface of a connective-tissue membrane. Once the epithelial cells transgress their membrane and become definitely and recognizably cancerous, there is no limit to be set for their continued invasion of the tissues regardless of their nature. The cancer cells grow into the tissues, whether cellular tissues, fat, bone, muscle, gland, or any other type, by the extension of processes from the initial mass or by the escape of one or more cells from the primary tumor and their lodgment in tissues favorable to their development; as the tumor invades or infiltrates the normal tissues they gradually become disintegrated and disappear, being replaced by cancerous tissue. In fatty tissue the cancer cells grow among the fat cells, sometimes surrounding them so that they appear as microscopic cysts, or occasionally invade their wall and fill the cell cavity. As the cancer cells multiply the fat is obliterated. So it is that cancer spares no structure, whether of active or passive function. It may, in addition to its direct destructive action by infiltration and pressure, act also indirectly in the destruction of tissue, namely, by destroying, collapsing, or blocking the vessels, causing necrosis. When cancer cells come into spaces or cavities they grow along the lines of least resistance more readily, but not exclusively. Hence, minute processes may extend along the anatomic spaces indefinitely, as was described under Sarcoma, or they may infiltrate the walls of blood-vessels and form root-like processes along the lumen of the vessels, blocking them and favoring thrombosis, or embolism, which latter serves as the source of general metastasis and is usually a rather late occurrence; or (and this is very common and may be very early) the lymph-spaces and channels may be invaded and the processes grow along these vessels and even reach to other organs and produce secondary tumors, which have been interpreted as the effect of emboli carried through the circulating blood. As an example of this cancer of the stomach, secondary to cancer of the breast, may be cited. These processes extend either with or against the direction of lymph-flow. They may be so exceedingly numerous and so well developed as to form a distinct network, as may be seen with the naked eye in the case of pleural lymph-channels. Among such network isolated individual secondary nodules often appear. It is such processes as these that can be squeezed from the lymphatics of the urinary bladder or stomach when cancerous. On reaching a lymph-node in the course of its extension such a cancerous lymph-channel process extends its cells along the space between the node proper and its capsule, the marginal sinus, and gradually ensheaths the lymphatic tissue, which it then proceeds to infiltrate and destroy. The capsule is also infiltrated and becomes attached to the surrounding tissues; it is as if a new cancer had established itself in this region. Now the cells may go from lymph-node to lymph-node, extending along the channel just as before, or they may escape and be passed along as lymphatic emboli.

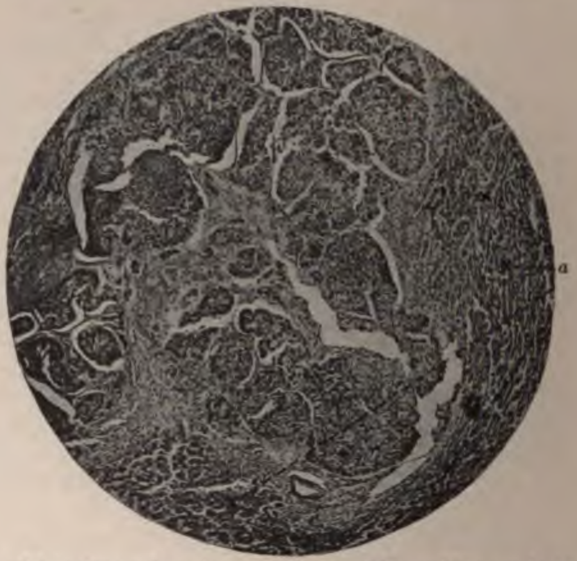

Fig. 197.—Metastases of carcinoma in liver. (Microphotograph; × about 50.)

Metastasis.—By the term "metastasis" is meant here, just as in the case of sarcoma, a secondary tumor which has formed from cells which have become separated from the primary growth. These cells may separate accidentally as the result of physiologic processes, for example, by the blood-current, or as the result of trauma. They are, therefore, favored by all undue manipulation, whether for the purpose of examination or otherwise; there is less danger in excising for microscopic purposes here than in sarcoma, but it is preferable, when possible, to use the same precautions that were recommended under that subject.

In cancer the most common secondary growths are due to invasion of the lymph-nodes. This may occur, as stated above, by direct growth of the tumor along the channel, or from cells which have escaped into the lymph-stream and gone as emboli to the first node, where they are checked and a new metastatic process is established; later by one of these plans the next node is invaded, and so on. If the cancer cells reach the last node in the chain they may escape from it and enter the blood through the thoracic duct or the right lymphatic duct. The metastatic invasion of lymph-nodes is usually only regional. Retrograde invasion of lymph-nodes is probably largely or wholly due to the growth of lymph-channel processes. General metastases are due to the entrance of cancerous emboli into the general circulation. They may occur through the lymphatics or, as is doubtless true in the majority of cases, by invasion of the blood-vessels by infiltration. Of course, the site of most frequent formation depends largely on the vessel through which the emboli were admitted.

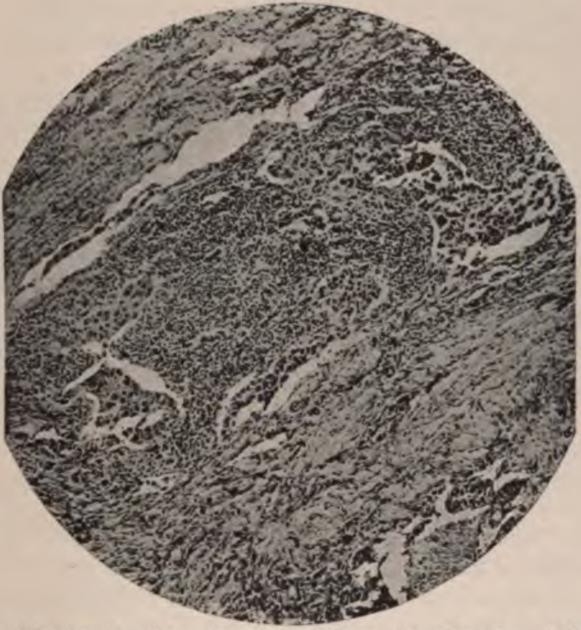

Fig. 198.—Metastasis of carcinoma in axillary lymph-node. (Microphotograph; × about 100.)

Secondary tumors also result from the contact of a cancerous surface with a normal surface, the latter ultimately becoming invaded; from the escape of cancer cells into a serous cavity, as pleura or peritoneum, on which they become implanted and grow; from the contact of cancerous tissue with the wound at the time of operation. These two latter points emphasize the care imposed upon the surgeon during such an operation.

Sites of Formation.—It is plain from what has been previously said of cancer that it can originate only from those structures which normally contain epiblastic or hypoblastic cells, from those which contain them in the form of vestiges of embryonic remains, anc from those which contain them by virtue of some accident in th development of the fetus. Hence it is that cancer originates wit impressive frequency in the skin, the mucous membrane, and th glands. It must be emphasized, however, that it does not ari from these sources only, for embryomata, dermoids, and embryon

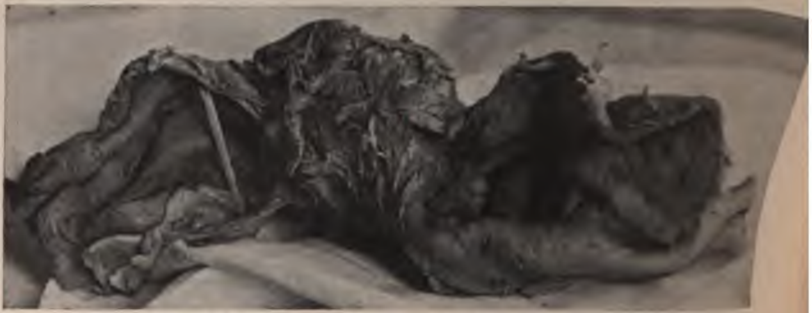

Fig. 199.—Cancer of the rectum.

remains give origin to it, as, for example, in unobliterated gill slits.

On the skin they arise with far greatest frequency on the exposed surfaces, namely, the hands and face; they are rarely found on covered surfaces of the body except in consequence of diseased conditions of the skin, already mentioned, which favor their development, and in scars. The penis is the most frequently affected of the covered parts, and the anus second. The factor of greater irritation of the anus and, in the uncircumcised, of the foreskin, and the constant evil action of uncleanly secretions, explains their prevalence at those two sites. On the face, the lower lip, the eyelids, and the skin just in front of and below the ear, as well as the ear itself and the alæ of the nose are the usual sites. Cancer of the face is much more common in men than in women in general, owing to their greater exposure to irritation, and cancer of the lower lip occurs twenty times in men to one time in women. These cancers of the skin often appear as rodent ulcers or, when arising from cicatrices, as Marjolin's ulcers.

In the mucous membrane of the alimentary tract the sites of greatest frequency are the mouth, especially the tongue of tobacco-using syphilitics, the esophagus, the stomach, chiefly at the pyloric end where ulcers are most common, the cecum and appendix, and the rectum.

The pyloric end of the stomach and the rectum are the two commonest sites of this group. In the genito-urinary tract the bladder is occasionally invaded and the uterus very frequently. The lungs occasionally give rise to primary cancer, but it is a very rare occurrence.

Of the glands, the breast stands easily at the head of the list, while separated by a wide disparity are the prostate, thyroid, salivary glands and the liver, kidneys, suprarenals, pancreas, ovaries, and testicles.

It may be repeated with reference to cancer that those organs which are least frequently the site of primary involvement are most frequently affected by metastases (hematic).

The structures affected by epithelioma are those which normally contain squamous-celled epithelium, and consequently are the skin, the mucous membrane of the mouth, and the portio vaginalis. However, the cells of many organs either have the capactiy of developing into squamous cells or they reach them from other sources, for many structures which normally show no squamous cells may occasionally give rise to squamous-celled cancer.

On the other hand, it must not be inferred that those structures which habitually give rise to epitheliomata can give rise to this form of cancer only, for carcinomata of unquestionable character may arise from the functionating epithelial cells contained in them.

Carcinomata develop with greatest frequency in the stomach, the mammary gland, and the uterus.

Diagnosis.—The signs and symptoms of cancer fall practically under two captions—epithelioma and carcinoma. This is especially true of the local manifestations. Those features that are common to the two will be discussed in common.

Epithelioma.—Owing to the vast importance of early recognition of cancer, it is necessary to refer to the appearance of beginning epithelioma. The conditions which so often serve as a starting-point of cancer have already been enumerated; the question that arises here is just what is the appearance of a beginning epithelioma, what evidences should lead one to suspect that the condition is malignant. The feature of the diagnosis of the local condition is of the greatest benefit, for thus early it alone serves to direct the attendant correctly; there are as yet no general symptoms. A beginning epithelioma may assume a variety of forms; for instance, it may start as a very thin, small scale appearing on the surface, which becomes loosened after a few weeks or months, only to fall away, leaving the surface practically smooth. This may be repeated a number of times and the scale may become gradually larger for a number of years, but producing no symptoms other than possibly a slight itching. Ultimately there may appear in the skin surrounding the scale small dilated blood-vessels which radiate more or less from it as a center; finally, the skin underderlying the scale begins to thicken and a definite but small mass forms in the corium. The same thing happens occasionally in the brownish verrucal patches that form on the extremities, face, and scalp of old people. Again, a keratosis, for instance, on the lower lip remains indefinitely, appearing somewhat as a thin dry corn. It does not come away, and if removed without the underlying mucous membrane it promptly returns. Exfoliation of the outer cells does not occur. Ultimately it begins to become thicker at the expense of the underlying tissue and has become cancerous. The same thing may happen to fissures, warts, moles, eczematous conditions, x-ray burns, scars, and leukoplakia. It is the thickening of the structures by the growth of cells into the supportive connective tissue which gives the first positive evidence of the true state of affairs. The surface lesion even early is likely to be coextensive with the induration produced by the growth of cells

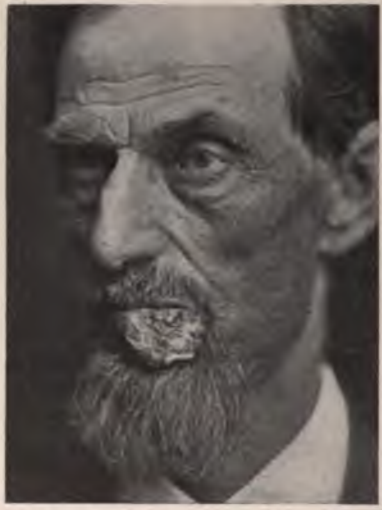

Fig. 200.—Epithelioma of lower lip before operation.

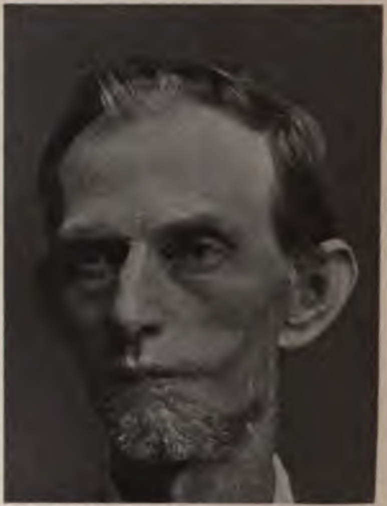

Fig. 201.—Case of epithelioma of lower lip (Fig. 200) after operation.

into the subepithelial structures. This extension of the mass into connective tissue, even though it be no deeper than the corium or the basement-membrane of the mucosa, is very valuable evidence, and should lead at once either to the more positive means of diagnosis or to proper treatment.

The appearance of epithelioma in the form of rodent ulcer or of Marjolin's ulcer should cause little difficulty of recognition if the age of the patient, the previous history of the case, the slow progress of the ulcer with practically no evidence of healing, and the induration and infiltration of the tissues more or less widely around the ulcer's margin and beneath its base be taken into consideration.

Epitheliomata are usually comparatively slow in their growth, requiring a long number of years, often as many as eight to twelve, to terminate in death. They vary in density, but as a rule are denser than carcnimoata, and sometimes are so hard as to present an almost cartilaginous resistance to pressure. The shape of the more common type of epitheliomata is usually not spheric, but more or less flattened or occasionally nummular, with edges that shade off imperceptibly or unevenly into the surrounding tissue; sometimes the whole ulcerated tumor is raised plateau-like above the level of the skin surrounding it, and limited by a hard ring of tumor tissue. Sometimes healing takes place over a portion of the ulcerated surface of flat epitheliomata, but the ulcerative process continues to spread in other areas and may return and attack the newly healed part. Their tendency to infiltration is no more marked, perhaps, but unquestionably much more frequently demonstrable clinically than is the case in the deeper tumors. This manifests itself by the immobility of the tumor and the want of evidence of encapsulation, but is especially noticeable when the superjacent layers of tissues are so bound together by it that they cannot be glided over each other. For example, in epithelioma of the cheek the growth penetrates to the mucous membrane and fixes it fast to the underlying tissue. By this means it is possible to recognize when infiltration has extended into an adjacent organ, as from uterus or prostate into the rectum.

There is a second form of epithelioma which assumes a massive, tumor-like appearance less likely by far to confine itself to the superficial structures than the flat epithelioma, and growing in all directions, not only deeply into the tissues, but rising in a rather uneven tumor above the skin level and assuming roughly a roundish shape. Its surface, too, is often ulcerated and resembles a fungus or cauliflower growth. Sometimes the ulcerative process extends deeply into its substance and produces a crater-like cavity. Moreover, the skin surface covering it may be ulcerated at various points in such manner as to remind one of ulcerated gummata (Kaufmann). This form of epithelioma is sometimes seen in vaccination scars.

A special form of cancer, sometimes assuming the nature of an epithelioma and, again, that of cylinder-cell carcinoma, attacks the nipple primarily, and is known as Paget's disease of the nipple. In this type the cancerous process begins either in the nipple or in the areola and may develop into a broad superficial tumor, or in other instances may grow into the breast proper and produce the same effect seen ordinarily in cancer of the breast. The cylinder-cell type, of course, arises from the lining of the lactiferous ducts.

Paget's disease of the nipple begins as an itching, eczematous, chronic condition. This spreads around the nipple into the areola and possibly the surface of the breast. The nipple ulcerates superficially and gradually shrinks and retracts. The process is slow, but, as a rule, gradually spreads from the point of the beginning. Occasionally the ulceration partially heals of its own accord.

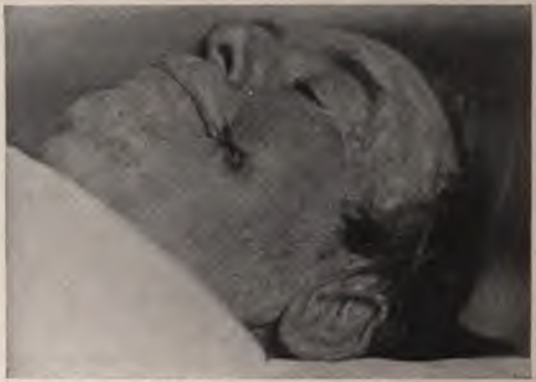

Fig. 202.—Epithelioma of cheek, recurrent after x-ray "cure." Before operation.

The remaining features in the diagnosis of epithelioma are identical with those of carcinoma.

Carcinoma.—Briefly stated, the clinical diagnosis of carcinoma may be given in the following words: That it is a rapidly growing malignant tumor of very variable size, whose essential element is glandular cells, occurring in people usually who are more than thirty years of age. It is, as a rule, painless at the beginning, but frequently becomes painful when well advanced or when certain complications arise. It grows by infiltration and spares no structure which it may reach. It is never encapsulated, never movable relative to the structure in which it appears, and, as it increases in size, firmly attaches the structures affected into a solid mass. The shape of carcinoma is less frequently round than is the case in other tumors. It grows flat, round, nodular, or irregular in shape, as circumstances may determine. Carcinoma readily and frequently undergoes degeneration in the older parts of the tumor, and hence is very prone to ulcerate. Having ulcerated, hemorrhage, especially if the tumor is connected with a mucous membrane, is very common and often characteristic. Infection gains easy access to the degenerating ulcerative surfaces, and decomposition, with foul odors and discharges, is marked and extensive. Suppuration is less common. The tumor may produce early or late lymph-node involvement; it occurs relatively late so far as treatment goes. Metastases through the blood are, as a rule, late, but there are important exceptions. Cachexia may develop at any time once a cancer is well under way; in uncomplicated cases it is often a very late and unreliable symptom. The average life of patients who have soft carcinomata ranges from six months to three years, and of those who have tumors with an abundance of connective tissue, or scirrhous cancers, it ranges from five to twenty years.

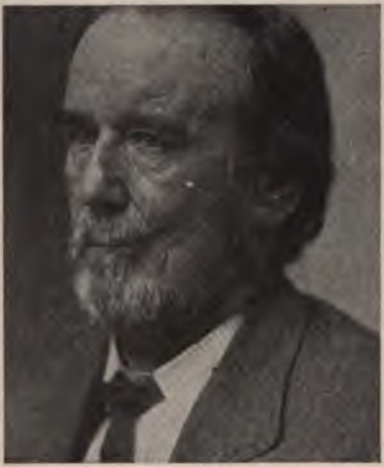

Fig. 203.—Case of epithelioma of cheek, shown in Fig. 202, after operation.

These items must now be discussed seriatim, for no adequate conception of the behavior of cancer can be gathered from so brief a narrative of its salient features.

Rate of Growth.—The broad statement that carcinoma is a rapid growth is, in the main, true. The rule is that it attains a given size much earlier than benign tumors do, but it does not attain so great a size as sarcoma or many of the benign tumors. It is rare, indeed, for one to find a single carcinoma of the size of a human head. On the other hand, we do not infrequently meet with carcinomata in the form of scirrhus which actually reduce the size of the organ in which they exist, although a definite tumor is found, as, for instance, in scirrhus of the breast. Again, the primary tumor may be so insignificant in size as to fail to produce symptoms or physical signs which could possibly direct attention to the structure containing the tumor, and only the secondary growths come to light, until a postmortem reveals the site of the primary tumor. Such tumors have been found, for instance, in the bile-channels and in the prostate. Hence, while on the whole it is true that cancer is a rapidly growing tumor, it must always be borne in mind that it may be slow growing and small; and in certain instances bear so little semblance to a tumor or be so obscured by accidents that have befallen it as to render it impossible to surmise in a clinical way that it is a tumor at all.

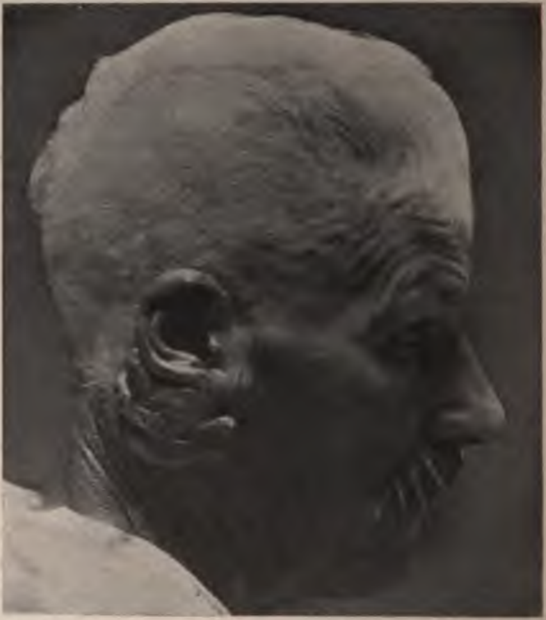

Fig. 204.—Epithelioma requiring removal of ear, parotid gland, and much surrounding tissue.

Surface Appearance.—The surface appearance of carcinoma is of value only when the tumor has invaded the skin or mucous membrane or when ulceration has occurred. In the former instance the surface is likely to be red, but it is not necessarily so, and has usually a more or less nodular appearance. When ulceration has occurred, one of two conditions is present: either the surface is covered with decomposing tissue and débris, or if it is clean the tumor may show a red, granulating cauliflower mass, from either of which there is a discharge of serous, sanious, serosanguinolent, or sometimes purulent fluid. The surfaces presenting the cauliflower appearance are indicative of actively growing tumor elements and usually bleed very easily and freely, especially on manipulation.

Consistence.—The consistence of carcinoma varies with its structure. The greater the quantity of tumor cells relative to stroma, the softer the tumor. These tumors cut easily and may be so soft and succulent as to be fluctuant. On the contrary, the greater the quantity of connective tissue, the harder and less fluctuant the tumor. Some of these cases have a distinct leathery or even cartilaginous feel. The presence, too, of cysts or of colloid substance in the tumor alters the consistency markedly, so that it is impossible to recognize the true nature of the growth simply by physical examination.

Cancer Period.—The age of cancer patients is usually more than thirty years, a fact that only emphasizes the need of great caution lest those which develop in younger individuals escape unrecognized. The different types of cancer and those occurring in certain structures are more frequent at certain periods of life. For instance, cancer of the skin occurs more frequently after the age of forty-five years; carcinoma of the breast is seen in women usually between the ages of thirty and sixty years; it rarely occurs later than this age, and is only very occasionally observed in women between twenty and thirty, very seldom in girls under twenty. Cancer of the stomach is more common between the ages of fifty and seventy years, and is very rare before the age of thirty. Cancer of the liver occurs at the average of 51.6 years in males and 44.7 years in females, if only those cases are considered which occur after the fifteenth year of age (Rolleston). A large proportion of cases of cancer of the liver in adults develop in cirrhotic livers. This is not true of hepatic cancer in the young. The above illustrations only serve to impress that once an individual has passed the cancer age the recognition of the nature of the trouble must depend almost if not altogether on other evidence than the decade of life. This is true in a more limited way of those who have not reached the age of thirty years.

Cancer occurs very rarely in the young; it is by no means limited to individuals beyond the age of thirty or even twenty years. The distribution of cancer in children is limited to a very few organs, being confined chiefly to the liver, alimentary tract, uterus, ovary, and skin. It may occur even during the first few months of life. It must, however, be emphasized again that cancer in the young is one of the very rare pathologic conditions.

Pain.—Pain in cancer, as in sarcoma, has been given, unfortunately, too great value as a symptom. It may be stated correctly either that pain is or is not a symptom of cancer. The rule is that cancer is painless at the beginning, and it often remains free from pain until long after the tumor has reached the inoperable stage. If this symptom be waited for to confirm the diagnosis, cancer statistics would appear much more hopeless than at present. When one considers how a cancer may produce pain, it becomes self-evident that pain would not usually appear as an early symptom. Pain is produced by the mechanical interference with function, as in the cases of stricture and obstruction of hollow viscera, by the interference with normal motility, as in case of infiltration of the bladder or rectum; by the presence of a previous condition on which the cancer has built and which of itself is painful, as in those cancers which develop on painful ulcers of the stomach; by infiltration or by compression of sensory nerve-fibers; and by such complications as ulceration and inflammation. These are either rare or late conditions, and it must follow that cancer is not painful in its early stages, when treatment offers most to the patient. This is borne out almost universally by the clinical history of the cases. But as the tumor advances, infiltrates, ulcerates, attacks other organs, metastasizes, becomes inflamed, or causes a narrowing of the lumina of hollow structures, pain may be not only present, but unbearable and unrelievable.

Encapsulation.—I have said already that cancer is a noncapsulated tumor. The only exception to this is in those cases where malignant cells have developed in a growth that is already encapsulated and have not yet had time to penetrate the limiting sheath. It grows habitually by infiltration and confines itself within no anatomic limits. Hence, there are two clinical signs of great importance: first, that cancer is not a movable tumor, or, what amounts to the same thing, namely, that when it invades a structure, that structure, as, for example, the mucous membrane of the rectum, no longer can be glided over the submucosa when it has been infiltrated by cancer of the uterus, bladder, or prostate. So, too, of the mucous membrane of the mouth or stomach. The second sign, dependent upon infiltration and absence of a capsule, is the indefiniteness of the edges of the tumor, so that one cannot determine by palpation just where tumor tissue leaves off. But the growth of cancer by direct extension may reach far and wide beyond any clinically expected limit, as is shown by the cases of invasion of the upper abdomen by cancer of the breast when all between the two growths is apparently normal; or by the affection of lymph-nodes by root-like processes growing along the lumen of the lymph-channels.

Shape.—The shape of cancer is, like some of its other characteristics, very variable. It may grow as a distinctly round, smooth tumor. This is exceptional, especially in the later stages. It may grow as a flat tumor, covering wide surface areas and refusing to invade the deeper structures extensively, as is shown by the flat epitheliomata of the skin; it grows often as a nodular mass, as is illustrated by nodular carcinoma of the liver; or, again, the tumor may be very irregular in outline, apparently growing in certain directions more readily than in others, or if scirrhus, by its contraction and destruction of tissue, accomplish the same result.

Consistency.—The consistency of cancer is just as variable as its shape. The slow-growing tumors are hard directly in proportion to the density of their tissue; the cellular tumors are soft or encephaloid. Besides this, the tumor may be either cystic or colloid, and thus become distinctly fluctuant uniformly or in spots.

Lymphatic Invasion.—Lymph-node involvement is one of the important diagnostic signs of cancer, although it must be looked upon as a relatively late sign, for enlargement of a node or group of nodes means that the tumor has reached that far at least. Absence of perceptible lymph-node enlargement does not mean that the node is not yet invaded; it is only presumptive evidence. It must not be concluded that every case of lymph-node enlargement in connection with a cancer indicates that they are cancerous; they may have been present from other causes and prior to its origin; they may, on the other hand, be subsequent to the origin of the cancer and still not due to cancerous invasion, but to an infection gaining entrance through an ulcer on the cancer. In case of doubt, it is better to assume that they are cancerous or to subject one or more of them to the microscope. The presence of adherent lymph-nodes would indicate that the capsules of the nodes had been infiltrated and that they were thereby attached to the surrounding structures. Lymph-node involvement may occur in several directions at once, and it does not necessarily follow the direction of the lymph-stream. Hence a thorough excision may completely eradicate the cancerous cells from one region, and failure or impossibility to do so in another determines the recurrence of the tumor. There is no limit to the number of lymph-nodes in a chain which may be invaded, for the growth extends from one to another indefinitely. For example, the entire series from clavicle to pelvis may be invaded from a pelvic cancer. It has been shown already that lymph-nodes may be invaded either by direct growth or by lymphatic emboli.

Metastasis.—Metastasis occurs either by distribution of cancer cells in the form of emboli through the lymphatics or the blood. The former has been sufficiently discussed under Lymph-node Involvement. Cancer cells gain entrance to the blood by invasion of the vessels, especially the veins, and possibly sometimes through the lymphatic trunks which pour their contents into the veins in the upper thorax. The distribution of metastases is accidental or selective. By the former term is meant that the metastasis develops where the embolus lodges, if the circumstances at that point are favorable to the growth of the cells; it is probable that large numbers of cancer emboli never grow after their lodgment. If the primary cancer is in the region whose veins empty into the portal vein, the majority of the metastases will appear in the liver; if they gain entrance through the veins of the general circulation, the emboli are more likely to lodge in the capillaries of the lungs. Hence it happens that the lungs and the liver are so frequently affected by secondary cancer. If the foramen ovale is

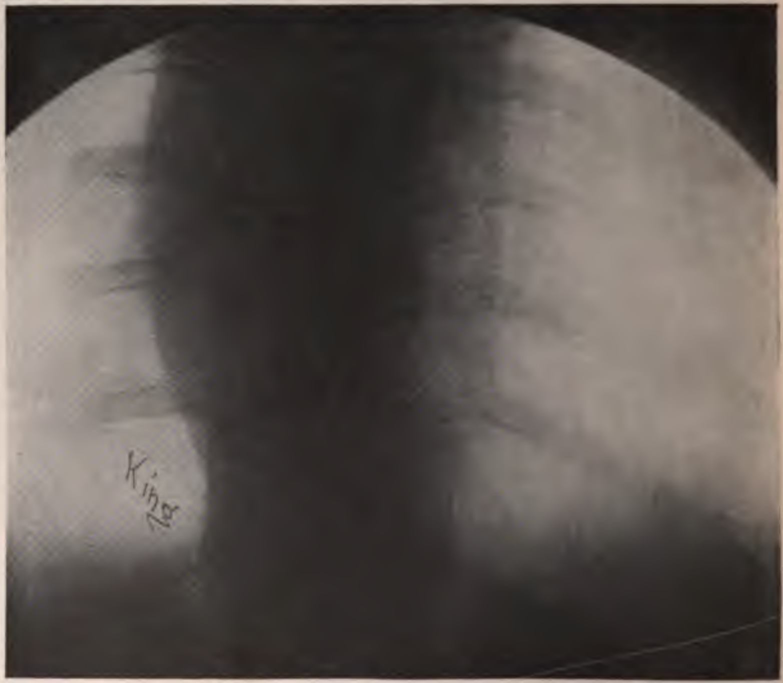

Fig. 205.—General skeletal metastases secondary to cancer of the breast.

patent, as it is in a large percentage of cases, the lungs may escape and a so-called crossed, or paradoxic, embolism may occur. The site of lodgment, *i. e.*, whether in capillaries or arteries, depends, as in other cases of embolism, on the size of the embolus. It is self-evident that death in these cases may result suddenly from embolism. Smaller emboli may escape the capillaries of liver or lung and lodge in peripheral portions. By the term *selective metastasis* is meant the tendency certain tumors show to produce metastases only in certain tissues or organs, aside from the accident of relative position in regard to the circulation. As the most notable illustration may be mentioned the frequency with which the osseous system is invaded by metastases in cases of cancer of the breast or of the prostate; skeletal metastases are more common in women. The bone may show simply a majority of the metastases, or they may be found only in the bones, if we exclude invasion of the lymph-nodes. Metastasis of the skeleton occurs with considerable frequency in cancer of the stomach, less often from cancer of the gall-bladder, uterus, intestines, esophagus, and skin. The bones most frequently attacked are the pelvic bones, the sternum, the spinal column, the femur, but the whole skeleton may be invaded, producing a condition which has been termed carcinomatous osteomalacia, in which the most bizarre and extensive deformities of the skeleton occur. On the other hand, spontaneous fracture, practically painless or much less painful than traumatic fracture, may be the first evidence that metastasis has occurred, or even the first evidence of the presence of cancer. Metastases of the lung are especially frequent in cancer of the stomach and of the thyroid gland. This is, however, probably accidental and due to no selective influence.

The time intervening between the escape of an embolus and its formation into a distinct tumor is very variable. It may occur in a short time under favorable circumstances, or where the inhibitive action is marked the metastasis may lie quiescent for years; the time limit, as usually accepted, is three years, but numerous cases of remote metastatic recurrence have been observed. Therefore the period during which metastases may lie quiescent is the measure of the time one must wait before pronouncing a cure.

There is no uniformity in the behavior of cancer relative to metastases through the blood. In one instance the tumor may be large and of long duration and produce no metastases, while another of recent origin or very small, possibly undiscoverable, may invade the entire body, the metastases first calling attention to the presence of a pathologic condition.

A type of metastasis or, more probably, a plan of growth sometimes observed is the separation of cancer cells from their fellows and their dispersion short distances from the primary tumor into the surrounding connective tissue, where they set to multiplying and produce new nodules. This is to be distinguished from those cases which grow diffusely through the lymph-channels and develop numerous nodules along their course, as is seen sometimes in cancer of the pleura.

The escape of cancer cells into a large serous cavity, notably the peritoneum, causes metastases on the membranous lining. The cells are distributed over the surface by the motion of its contents and become engrafted and grow. The tumors may be so small and numerous and so closely resemble tubercles as to lead the surgeon to give a diagnosis of tubercular peritonitis. The normal erect position of the body causes the cells to settle in the culdesac of Douglas, and this is the most frequent site of secondary cancer of the peritoneum. The next point of frequency is the furrow along the line of attachment of the mesentery to the gut, a position which, once attained by the cancer cells, fairly well secures them against displacement. As the individual masses grow they coalesce and ultimately so shorten the mesentery as to draw the alimentary tract close down to the line of mesenteric attachment to the posterior abdominal wall. Peritoneal cancer is accompanied by ascites, which is often bloody.

When cancerous metastases occur in great numbers they may be exceedingly small and widely distributed throughout the organs of the body and rapidly result in death. The condition is termed *general carcinomatosis.*

Implantation carcinoma is a secondary form in which cancer has become implanted upon a new site by contact and the deposit of some of its cells, which have taken and grown as a graft. The practical importance of this possibility cannot be overestimated. He who, while operating for cancer, cuts or tears into the tumor substance and thus allows tumor cells to be displaced into the wound stands in great danger of seeing an implantation recurrence. The same thing may happen in removal of a visceral cancer which is allowed to touch the wound edges; a case of Kelly's showed recurrence in the cicatrix, although the pelvis from which a cancerous uterus was removed remained free. In aspirating for cancerous ascites cancer cells may be lodged in the track made by the needle and develop into a secondary tumor.

It has been stated already that cancer cells grow either in their primary or secondary position with very variable readiness. As the patient becomes more poisoned by the presence in his body of a cancer, by anemia, by hemorrhage, ulceration, or infection, as, in a word, cachexia develops, the tumor cells meet with less resistance on the part of the tissues and the tumors grow much more readily.

Degeneration.—Degeneration of cancer tissue, whether of the parenchyma, stroma, or both, is a very common occurrence. It is almost universal in those tumors that have reached a relatively large size, and is due, as has been explained already, to the insufficient circulation of blood in the central, older portions of the tumor. Two important facts have their foundation on this tendency to degeneration: one is that the tumor grows only from its living undegenerated peripheral cells and that specimens for microscopic examinations should be chosen from an outer zone; the second is the tendency for cancers to ulcerate and be extensively destroyed by this process. A third, of minor importance, may be mentioned, namely, the change produced in the consistency of the tumors by degenerative action.

Ulceration.—Ulceration is a very frequent complication of cancer, on which frequently depends the very first evidence that the tumor is present. This is so emphatically true that in concealed cancers of the mucous membrane the discharges from an ulcerative surface are uniformly sought for as clinical evidence. This is especially true of cancer of the stomach and of the bladder. When the tumor is situated superficially or when by infiltration it ultimately invades skin or mucous membrane, ulceration is very likely to occur. It does not occur in cancers of the deeper structures unless the tumor has been inadvertently incised by the physician. Then, of course, if it is rapidly growing, it immediately pushes its way through the incision and forms a fungoid mass. When ulceration begins in a cancerous mass it continues indefinitely; the ulcer may be covered with decomposed tissue or may suppurate more or less extensively, or its surface may be rather clean, showing the red, raw, growing mass of cells. In the majority there is no tendency for epithelium to build over this surface, although this does occasionally happen imperfectly in some of the more slowly growing tumors, such as Paget's disease of the nipple. The ulcerative process may almost keep pace with the rate of growth of the tumor, so that there is only a small zone of cancer cells surrounding it, as is seen in rodent ulcer, or it may invade it imperfectly, so that in spite of prolonged ulceration a considerable tumor mass remains. The central ulcerative area is sometimes surrounded by several smaller ones.

Hemorrhage.—In consequence of the ulceration of cancer several other important symptoms develop, namely, hemorrhage, escape of serum, infection, necrosis, and stench, all of which play an important rôle either directly or indirectly in the local and general symptomatology of cancer.

Necessarily, hemorrhage is to be considered in any case of ulcerative cancer. It plays a much less important part in non-ulcerative cancer than it does in sarcoma. The hemorrhage varies with the site of the cancer, the nature of the growth, and the source of hemorrhage, *i. e.*, whether it comes from the vessels of the cancer itself or from some important vessel that has been attacked. Surface cancers that are ulcerated, of course, bleed somewhat, but it is unusual to see dangerous hemorrhage from them, partially owing to the fact that they are usually superficial to the amount of connective tissue they contain, and to the ease of recognition and the accessibility to treatment; cancer of the stomach, the uterus, and the bladder are very prone to bleed, and in these organs the suspicion of the patient is first aroused and the clinical picture frequently made clear to the physician only by the presence of hemorrhage. Hence the necessity of examining the stomach contents or feces in suspected cases of gastric cancer. It is necessary to exclude all hemoglobin contained in the food from the alimentary tract before the finding of minute quantities of blood can be relied on. So, too, the urine is examined for blood in suspected cancer of the bladder. It cannot be too emphatically stated, however, that negative findings in any instance are not to be accepted as an assurance that cancer is not present. Likewise the presence of blood may be attributed to many other causes than cancer. Hemorrhage is only one of the possible signs of cancer. Aside from its diagnostic importance, hemorrhage may become an urgent and uncontrollable complication, being one of the most frequent causes of death in cancer, or it may by the slow loss of small quantities of blood gradually exhaust the strength of the patient and add to the cachexia so often seen in advanced cases. The hemorrhage may come from numerous oozing points and be caused by the slightest manipulation or by some effort of the patient, but independently of all extraneous causes they bleed of their own accord; again, the hemorrhage may be profuse and from one or more larger vessels of the cancerous mass or of the region in which it rests.

The same influence produced by slow hemorrhage may be produced also by the continued leakage of body fluids from the ulcerative surface with little or no attendant hemorrhage.

Infection.—Infection is another complication arising early after the advent of ulceration. Both pathogenic and saprophytic bacteria may enter, and the dead, degenerated tissues of the tumor offer them, especially the saprophytes, an excellent field for development. Inflammation and suppuration may, therefore, appear as a complication of cancer, but the saprophytic bacteria are responsible for the more characteristic decomposition and stench, which is often so intense as to be unbearable, working the greatest hardship on both patient and attendants. The obnoxious effect of the malodor of cancer, especially cancer of the uterus, cannot be exaggerated.

Cachexia.—Cachexia is a reliable general symptom of cancer, but when it appears sufficiently marked to be of great value the case is usually advanced beyond the hope of recovery. It is, therefore, not to be waited for; it would be indeed fortunate if the symptom could forever pass from the literature of malignant tumors. Cachexia does not show early; it may even not appear until a few weeks or months before death. There can be no doubt that cachexia may be produced by cancer pure and simple. Likewise there is no doubt in the minds of those who study the clinical course of large numbers of cases that it is very often largely attributable to accidents or complications. Hence it is that the patient may continue in fair general health, weight, and appearance for a long period of time, and then suddenly develop cachexia in the course of a few weeks. Hemorrhage, whether continuous and slight, or large and repeated, the loss of body fluids in the form of serum or pus, the deleterious effect of ptomains and toxins from an ulcerated surface, and the interference with normal vital functions are the common factors aiding in the causation of cachexia. Hence the patient who has cancer of the mouth, esophagus, or upper intestine starves, and the one who has cancer of the rectum is cachectic, partially because he cannot secure proper motions and becomes auto-intoxicated from retained feces. So, too, the prostatic and bladder cancers interfere with general nutrition by retention of urine and by the encouragement offered to infection of the bladder and kidneys. It is of great prognostic importance to be able to say whether the cachexia present in a case of cancer is due chiefly to the cancer or to some incidental occurrence, for in the latter instance it is often possible to eliminate the cause, build up the general condition of the patient, and relieve him by a satisfactory surgical procedure, while in the former such a course will rarely be feasible.

Fever.—The temperature is usually undisturbed by the presence of cancer except in those cases, of course, where complications arise which, independently of the tumor, produce fever. There are exceptions, however, as carcinoma may cause a moderate febrile reaction occasionally. This is especially true of general carcinomatosis. The fever may be continuous and must be differentiated especially from malaria and sepsis.

Anemia.—The blood changes of cancer are important, though not characteristic. The anemia may assume a mild chlorotic form or be a facsimile of pernicious anemia, the former in the acute, rapidly growing, metastasizing growths, the latter in the slow-growing, chronic forms, among which latent cancer must not be forgotten. This is paradoxic, but largely borne out by clinical findings. The anemia of cancer may be said to go hand in hand with cachexia and to be, indeed, a part of it. The same causes which, in addition to the presence of malignant tumor, intensify the cachexia, increase the anemia. Thus hemorrhage, wasting of body fluids, interference with correct elimination, and the absorption of poisonous products are responsible for both conditions. The red cells may be reduced to 2,500,000 or even as few as 1,000,000. The white cells may be relatively or absolutely increased. Leukocytosis, when present, is usually due to a larger percentage of polymorphonuclears, but there are exceptions. Leukocytosis is more often present in rapidly growing tumors. "Myelocytes are perhaps more frequently found in cancer than in the other types of anemia, excepting pernicious anemia and leukemia" (Webster).

Multiple Primary Growths.—Cancer usually occurs as a single primary growth, although there are numerous cases recorded in which there were primarily two, sometimes several, growths occurring at or about the same time and, without question, independent of each other. Or they may appear successively at varying intervals and affecting the same structure or widely separated structures. They may occur in a given tissue and be close together and due to the same apparent cause, or widely apart and from, so far as we know, entirely different causes. The most frequent site of multiple primary cancer is the skin.

Cutaneous Reaction.—The diagnosis of cancer by the attempt to elicit cutaneous reactions has recently been the subject of extensive research, but is not established with sufficient accuracy to demand a discussion in this text.

Special Symptoms of Cancer in Various Organs.—The symptoms and signs of cancer discussed above are dependent upon the presence of cancer and the accidents and complications that may befall it in a general way. There are, in addition to these, other special signs and symptoms of varying importance attaching to cancer of various organs and often of the utmost diagnostic value, especially where the cancer is so concealed as to be inaccessible to the usual means of examination, and where the more apparent symptomatology might arise from other causes than cancer. It is necessary to discuss briefly the more important special facts in connection with cancer of the various organs, especially those more frequently attacked.

Breast.—Cancer of the breast arises usually, except in Paget's disease of the nipple, as a single nodule situated in the breast more

the nipple and more frequently
ter quadrant than in any other.
inner quadrant and the rest near
h varying rapidity and may reach
As growth continues the nipple
mpletely submerged below the
racted nipples are not to be taken
nay be present, either unilateral
efore the retraction is apparent
way from the tumor, feel a cord-
to the tumor, and this, when
is known as Halsted's sign.
be invaded, becoming thick-
the subcutaneous tissues and
eel, especially if an attempt is
reddened when it is invaded.
of the breast together into a
breast to the pectoral fascia,
ven lung. The nodes com-
ed are the subpectoral nodes
vicular nodes are not infre-
ence than axillary involve-
is invaded, and rarely the
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he mediastinal nodes are
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downward below the breast in the form of nodular cords on both sides in the skin and beneath it over the abdomen to the greatly enlarged inguinal lymph-nodes. There were numerous metastases in the bones."

As the growth of the cancer continues the muscles allow less and less use of the arm, and when the axillary vessels are compressed or invaded the arm, forearm, and hand may become enormously swollen and useless on account of edema.

Scirrhus.—Scirrhus has already been sufficiently described. One form of it deserves especial mention, namely, the so-called *cancer en cuirasse.* Scirrhus may produce an infiltration or induration of the skin, which extends widely over the thorax or may even entirely surround it, drawing so tightly down upon the thorax and its muscles and vessels as to produce marked restriction of movement, impair respiration, and cause intense edema of the upper extremity. The condition is usually preceded by a discoverable tumor in the breast, although in some instances the tumor appears afterward; rarely cancer en cuirasse develops after an operation for scirrhus. It is due to invasion of the lymph-channels and the formation of connective tissue in the affected region. The skin becomes hard, brawny, leathery, thickened, often pigmented, and may show dilated veins over its surface. At the beginning the condition is manifested by the development of reddish spots in the region of the breasts; gradually these spots become thickened and larger and may have a nummular shape. Their size varies from ½ inch in diameter down to the size of a mustard seed. They may be numerous and become confluenct. These nodules may be inclined at times to be in groups. Occasionally ulceration is observed in one or more of them.

Colloid cancer of the breast is very rare.

The metastases of cancer of the breast produced by emboli in the blood-vessels are more frequent, naturally, in the soft cancers, which are more abundantly found in young women; they are least frequent in the scirrhous forms. The pleura, liver, osseous system, and pelvic organs are the structures more commonly invaded. The stomach may rarely be invaded secondarily to cancer of the breast. This may be due to embolism or to extension of the growth along the lymph-channels. The latter is probably more likely to occur in scirrhus.

Uterus.—Cancer of the uterus may arise either in the cervix or the body, and may be epithelioma, adenocarcinoma, or the papillary type (cauliflower). Cancer of the cervix is much more common than cancer of the body, and is relatively more frequent in women who have borne children; they are also more commonly of the squamous-celled type. Cancer of the uterus may occur at any time during the cancer age, but it is more common in women who have passed the menopause. The most important fact to be learned on this subject is that a recurrence of the flow after establishment of the climacteric is usually due to cancer. If it is necessary to investigate menstrual disturbances prior to the climacteric, it is absolutely imperative to spare no means to eliminate cancer in the woman who "menstruates" after this period.

Infiltration of cervical cancer occurs along the vagina and into the bladder, rectum, body of the uterus, and the parametrial tissues. The peritoneum may be secondarily invaded, sometimes in the shape of diffuse peritoneal carcinosis. The cervical canal may be stenosed, establishing a pyometra. The ureters may be compressed, causing hydronephrosis. When the bladder and rectum have become invaded, interference with their function may be marked and the pain and distress very annoying. As the hemorrhoidal veins become obstructed hemorrhoids develop only to add to the distress. Later, fistulæ between bladder and vagina or between rectum and vagina may form and add their quota to the already intolerable misery. The hypogastric and sacral lymph-nodes are the first to be involved in cervical cancer, later any of the higher groups in their order may be reached—iliac, lumbar, portal, bronchial, tracheal, and supraclavicular.

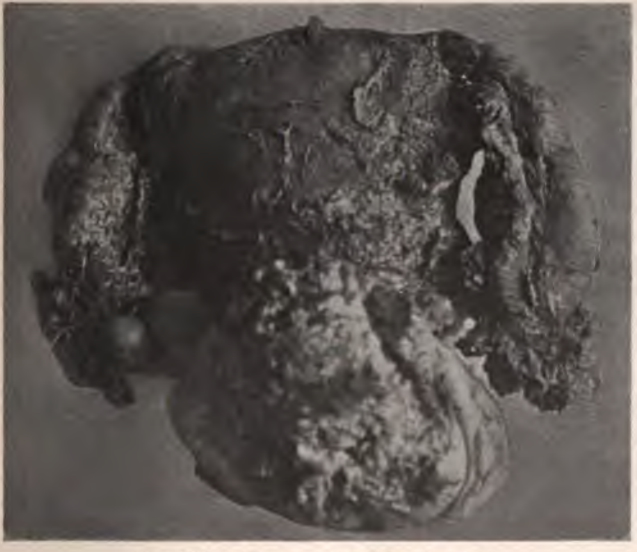

Fig. 206.—Cancer of the cervix uteri.

Carcinoma psammosum is a squamous-celled cancer or adenocarcinoma of the uterus in which concretions have been formed. It is rare.

Metastases are found in about one-third of the cases of cervical cancer, and are found more frequently in the liver and lungs.

The body of the uterus is affected by cancer only about one-tenth as frequently as the cervix. It appears usually as a more or less nodular growth, but sometimes grows rather diffusely. The uterus is usually enlarged, perhaps to the size of a cocoanut or a half-gallon measure; on the other hand, it may show no enlargement.

The important symptoms of the advancing growth of cancer of the uterus are pain, discharge, hemorrhage, stench. The less they are perceptible, the more fortunate, for at its best the history of uterine cancer is one of the saddest in the annals of surgery. This is so true that every case of the least suspicion should be subjected frequently to thorough examination.

Stomach.—Cancer of the stomach is very frequent. It constituted 28.66 per cent. of all of Kaufmann's cases of cancer in Basle, and 37.22 per cent. of all his cases in Göttingen. Combined statistics show that 33 per cent. of 70,000 cancer cases were gastric. They are the cause of 1 death in every 75. This postmortem finding is a sad commentary on the disproportionate number diagnosed *intra vitam*, and should be an unqualified stimulus to search along more fruitful lines for the real cause of trouble in our stomach cases. Cancer of the stomach is more frequently seen between the ages of fifty and seventy years, and is very rarely observed in patients younger than thirty years. It is found in men more frequently than in women, about 65 to 70 per cent. being in the former. The more acute cases of gastric cancer run a very rapid course, terminating in death in six or eight months; the chronic or scirrhous type lasts several years. The average duration of gastric cancer is about two years.

Gastric cancer follows upon ulcer of the stomach in more than half the cases, and is accordingly more commonly located at or near the pylorus. It is also said to be preceded frequently by gastric catarrh, especially the type of gastric catarrh caused by drinking alcohol. Many cases originate without a history either of catarrh or ulcer.

The most important facts to be borne in mind concerning cancer of the stomach are that there is no means of making a correct clinical diagnosis while the cancer is in an operable state; that, therefore, questionable cases should be subjected at the earliest possible time to exploratory incision; that gastric tests and clinical analyses, except when they show blood, are very unreliable data, misleading perhaps as often as they are correct, or even oftener.

The important symptoms of cancer of the stomach are often wanting and the patient complains only of "indigestion," which may not be severe enough to lead him to consult his physician. The presence of blood in the stomach contents is a very important symptom, whether it be shown by microscopic examination, by hematemesis, or melena; severe or fatal hemorrhage is comparatively rare. The absence of hemorrhage proves nothing except that if cancer is present it has not yet reached the point of ulceration. The appetite is lost early in two-thirds of the cases. Flatulence is a very common early symptom, and after ulceration and decomposition begin, the eructed gas may be foul. Pain is often the first symptom, perhaps in one-third the cases, or there may be simply a sense of discomfort in the epigastrium after meals prior to the onset of pain. From 10 to 25 per cent. of the cases never complain of pain. When pain is present it may be continuous or periodic; it may occur after meals or at night; there is no characteristic pain in gastric cancer either as relates to its presence, its time of occurrence, its nature, or the digestion of food. Emaciation is naturally an important symptom, and often is the first to direct attention to the possibility of a serious lesion, but it may occur only late. As decomposition and stagnation of the stomach contents occur, vomiting, inanition, weakness, and all the general symptoms follow. It is here, too, that characteristic

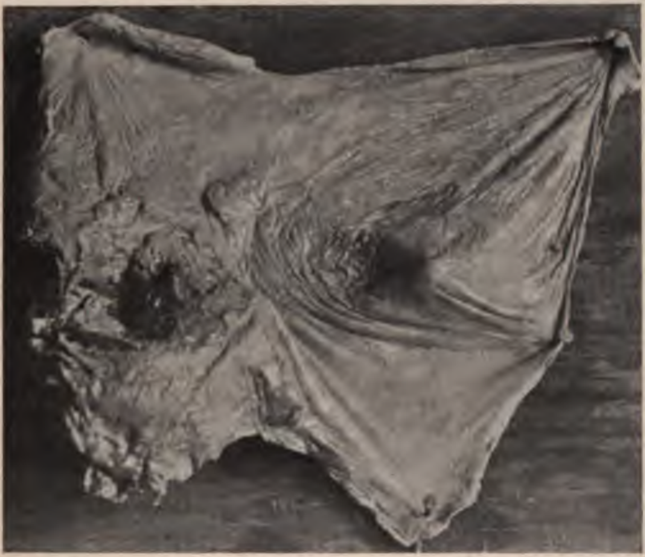

Fig. 207.—Cancer of pyloric end of stomach. Cardiac opening at right.

analyses of gastric contents are to be found. Symptoms of pyloric obstruction may be so marked as to dominate all others. Metastases from gastric carcinoma are very common and may appear before any evidence of a primary growth is at hand. The liver and the peritoneum are most frequently invaded; the lungs, the kidneys, the ovaries, and the osseous system are also rather frequently invaded.

Lymph-node involvement is first observed usually in the nodes at the smaller curvature, and then other groups of nodes, the subpyloric, the portal, the retroperitoneal, the mediastinal, and the supraclavicular (4 per cent.).

Bladder.—Cancer of the urinary bladder is recognizable only by microscopic examination, as it cannot be distinguished from papillomata in a clinical way. Indeed, many of the so-called papillomata of the bladder are to be considered malignant or certain ultimately to become malignant, though they may not be demonstrably so at the time of examination. The passage of blood or fragments of the tumor in cancer of the bladder is likely to be the first evidence of its presence, and this should lead to a complete cystoscopic examination. Tumors of the bladder are as yet not understood sufficiently to enable one to discuss them in an advantageous way. Some that show benign under the microscope recur even without the presence of clinical evidence of malignancy. Some authors straddle the situation by calling the questionable cases papillomatous disease of the bladder.

Liver.—Carcinoma of the liver is so rare as a primary growth as to merit but little discussion here. It is found usually in the old, but occasionally in the extremely young, even down to the first few months of life. It is exceedingly frequent as a secondary tumor, being found in 26 per cent. of all cases of cancer coming to postmortem. The primary growths assume various forms: first, the massive type, which may appear as an isolated mass or be surrounded by a group of secondary nodules. This tumor may attain the size of a child's head, appear nodulated or smooth, and be pseudofluctuant. Second, in cirrhotic livers the tumor may appear as a diffuse growth, as multiple nodules, or a combination of the two, *i. e.*, an infiltrative nodular form. In this the liver may be enormously enlarged, reaching sometimes the weight of more than 20 pounds. From a microscopic standpoint the tumors are of the alveolar type, the cylinder-celled type, and adenocarcinoma, the latter being the common form found in cirrhotic livers.

The secondary growths occurring in the liver are sometimes umbilicated, a condition rarely observed in the primary forms.

The symptoms of cancer of the liver are not characteristic.

The first sign of the trouble may be either an anemia or an enlargement of the girth. This increase in the size of the abdomen is due to the enlargement of the liver and to ascites, if the latter is present. In spite of the emaciation, the size of the tumor and the volume of ascitic fluid may cause an increase in the patient's weight even during the last few months of life. Pain is present in the majority of cases when the liver capsule is distended or its peritoneal coat invaded. There are exceptions even in enormously distended livers. Tenderness may be present, and is more likely if the peritoneum is affected. Friction fremitus may be elicited in the latter instance. Fever is present and continuous in a goodly number of cases, explainable on no other grounds than the presence of the tumor. Jaundice is often present, but not constant, and is greenish in contrast to the yellow jaundice of cirrhosis; it may be replaced by a sallow, muddy complexion. The patients are extremely weak. Ascites is often present, but only when obstruction is sufficient to interfere materially with the portal circulation; it is not essential. Hemorrhoids and edema of the feet may likewise develop. Metastases occur chiefly in the lungs or in the liver itself, the former from entrance of tumor cells into the hepatic veins, the latter from their entrance into the branches of the portal vein. Lymphatic invasion is rare.

Cancer of the gall-bladder and bile-ducts was found in 5 and 6 per cent. respectively of the cases in the Basle and the Göttingen laboratories. They are nearly always sequent upon gall-stones, although a few cases are found in which no gall-stones are present and which have no history of symptoms that would indicate gall-stone disease. The tumors originate usually about the neck of the gall-bladder, but the fundus may be the site of origin. The tumor may grow diffusely or in the nodular form. The gall-bladder is frequently distended and palpable, the contents being pus or saniopurulent fluid. On the other hand, the cancerous gall-bladder may be exceedingly shriveled and small. Secondary nodules may form in the mucosa of the common duct and result in the most intense jaundice. Jaundice may also be due to associated catarrhal inflammation of the bile-passages or to stones. In the two latter instances it may disappear after a time, but when due to blockage of the ducts by the tumor it is continuous and progressive. Distention of the gall-bladder occurs in a small percentage (less than one-fourth) of the obstructions to the common duct by stone, and in the majority of cases (more than three-fourths) produced by other forms of obstruction (Courvoisier's law). The beginning of cancer of the gall-bladder cannot be distinguished from cholelithiasis. It is only when the nodules appear locally and cachexia develops that one may be reasonably certain. The liver is often infiltrated, and the growth, unlike cancer of the liver, spreads preferably through the lymphatics. Hence the portal lymph-nodes and viscera adjacent to the gall-bladder are often the site of secondary tumors. The peritoneum may be locally or generally attacked, and the pelvic organs, especially the ovaries, often contain metastases. Cancer of the gall-bladder is more frequent in women. The usual forms are the cylinder-celled and the round-celled (glandular carcinoma), either of which may be colloid or scirrhous, and more rarely the squamous-celled form, which is presumably possible in such structures by metaplasia.

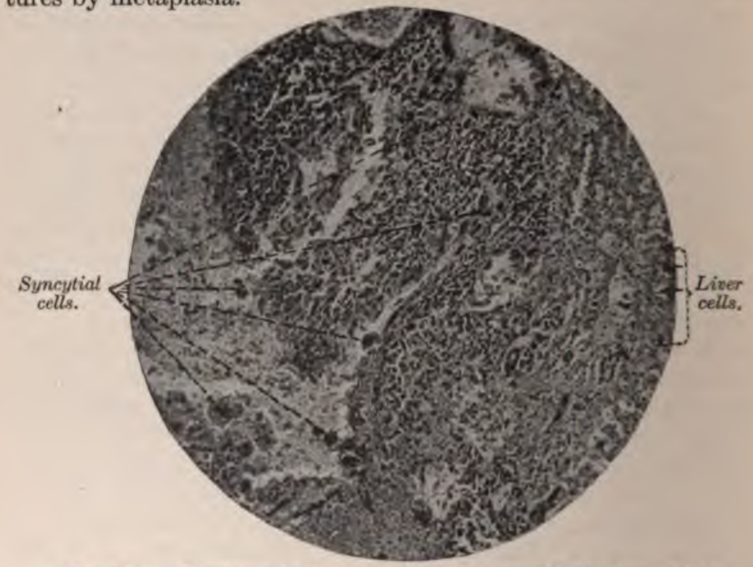

Fig. 208.—Chorioma in liver. (Microphotograph; × about 100.)

Intestines.—Cancer of the intestines may produce, in addition to the usual signs and symptoms of this tumor, some form of intestinal obstruction by compression of the lumen, by stenosis due either to the growth of the tumor or to the contraction of the new-formed connective tissue, or by volvulus and adhesion. However, it is marvelous to what extent the alimentary tract may be invaded without symptoms of obstruction arising. When intestinal obstruction from this source arises it may be either acute or chronic.

Chorion Epithelioma.—One type of cancer remains to be discussed briefly, namely, malignant chorion epithelioma, or syncytioma malignum. This tumor arises only from the epithelial cells of the chorionic villi, the syncytium. These tumors occur only in women who have been pregnant recently, whether that pregnancy was intra-uterine or extra-uterine; whether it was terminated by an abortion or by normal labor, and in women who carry a hydatid mole or who have recently been delivered of one. The tumor may originate before the delivery of a mole (malignant hydatid mole) or after its delivery. It is instructive to note that half the cases of malignant chorion epithelioma are associated with or follow hydatid moles. The development of chorion epithelioma takes place by an exaggeration of the normal cellular processes of pregnancy. Normally the chorionic villi penetrate through the uterine mucosa into the superficial (internal) muscular layers and into the veins. The villi when normal may even yield small emboli, which, carried by the venous blood, lodge in the lungs and disappear. In the development of chorion epithelioma the masses may grow through the whole musculature of the uterus, and the growths into the veins are coarse and numerous. The nature of the growth and its behavior toward the veins render it likely to be confused with sarcoma; it has, indeed, been mistakenly named sarcoma deciduocellulare. The readiness with which the veins are penetrated accounts for the early metastases, the tendency of the primary growth and its metastases toward hemor-

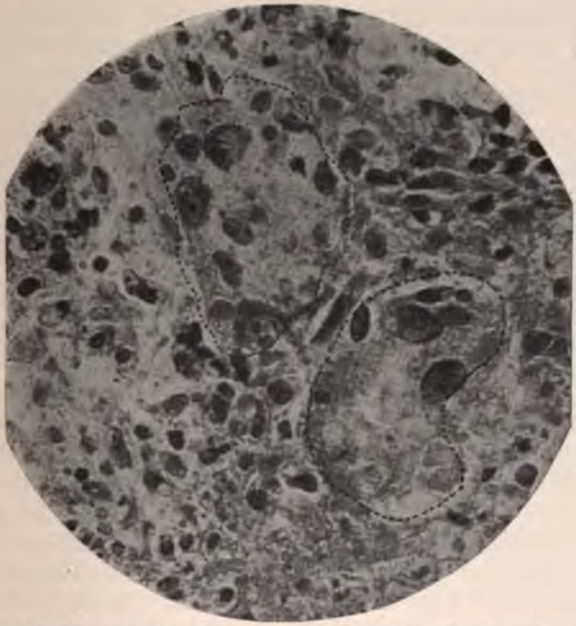

Fig. 209.—Chorioma in liver. Same as Fig. 208. Showing large multinucleated wandering syncytial cells. (Microphotograph; × about 250.)

rhage, for the variegated color of the cut surfaces, red, yellow, and mottled, and for the early metastasis and the rapidly fatal termination and the hopelessness of the condition. Metastasis occurs very early, and is usually already present when the tumor is discovered. These metastases are most common in the lungs where they may cause hemoptysis; the next site is the vagina, in which they form, it is claimed, by reverse flow in the vaginal veins. The brain is also a frequent site of metastasis and so are the kidneys; in the latter it may be first shown by hematuria.

Chorion epithelioma manifests itself at any time during pregnancy, normal or abnormal, or in from two weeks to several years (four) after delivery, miscarriage, or abortion. The earliest symptom may be either pain or hemorrhage. The pain is felt in the pelvis and in the sacral and lumbar region, and may be moderate or severe. Hemorrhage is an important symptom, profuse, intermittent, and unyielding to the usual means employed for its control at such times. In malignant hydatid mole, or where the syncytioma is present at the time of labor, fatal postpartum hemorrhage is probable. Between the hemorrhages there is a continuous foul watery or sanious discharge. Soon decomposition, stench, and passage of disintegrating clots occur. The remaining symptoms are such as attend cancer of the uterus, but are intensified. The patient rapidly becomes cachectic, emaciated, and progressively weakened, dying in a few weeks, or at most in a few months from hemorrhage, exhaustion, or embolism. This is the most rapidly fatal form of malignant epithelial tumor.

Variations.—Cancer may be predominantly cellular, the medullary type; or it may contain relatively few cells and an abundance of stroma, scirrhus; or these elements may be rather equally distributed throughout the tumor, the simple form of cancer. The arrangement of cells relative to the stroma may give the suggestion of eggs in nests, nest-celled cancer. Cancer does not appear often as a mixed tumor, for the cancer cells usually soon dominate the field even in those cases where the malignant growth develops on a pre-existing benign growth. The important lesson in this connection is that the cancer may be confined to a limited area of a pre-existing lesion, ulcer, tumor, or cyst, and a definite answer cannot be made by the pathologist without extensive section of the growth. In every case where microscopic diagnosis must be depended on, the entire tumor should be submitted, or the section should be chosen from the more suspicious region and from a growing portion, not from the older portions of the tumor, which may have degenerated to such an extent as to lose all their characteristic features. It is easy to understand how a microscopic examination may in the most skilful hands show no evidence of cancer when small specimens are selected at random, as from uterine scrapings. The statements made concerning microscopic diagnosis in the chapter on Sarcoma obtain here, with the exception that there is less danger probably of exciting metastases by excising portions of cancer than is the case in sarcoma.

Cancer rarely appears as a mixed malignant tumor, carcinoma sarcomatodes, in which the sarcomatous cells arise as a true blastomatous development from the cancer stroma. Another very interesting possibility in the lodgment of cancer metastases is a pre-existing benign tumor.

The pathologic changes which befall cancerous tissues are determined by their position relative to a mucous or cutaneous surface, the structure in which they appear, and certain accidents which may befall them.

Ulceration is the most frequent accident of skin cancer, being almost universal; it is likewise very common in cancers affecting mucous surfaces. Traumatism, infection, and the action of digestive fluids on necrotic tissue play their respective parts in the production of ulcer. Necrosis of cancerous tissue is exceedingly common, especially in the larger growths, not from a want of an adequate vascularization, but from the fact that there is no definite arrangement of these vessels which will determine a steady flow of blood. Fatty degeneration is a very frequent change, especially in cancer of the skin or of the breast. Myxomatous and colloid changes are occasionally seen.

Infection, inflammation, suppuration, and gangrene of exposed cancerous tissue are very frequently observed.

Prognosis.—The prognosis depends upon the type of the tumor, its location, its complications, and the stage of advancement at the time application is made for treatment. It also depends partially upon the age and general condition of its host.

The outlook for untreated cancer is altogether bad, for every untreated cancer, nay more, every cancer whose treatment is not undertaken prior to a certain state of its development, is sure to kill; and it is indeed imperative that we understand that in consequence of our inability to recognize cancer early in many of its locations, the tendency on the part of patients to conceal suspicious growths, and the ignorant advice of friends and unfortunately sometimes of medical attendants to await development, the mortality from cancer in general is probably far in excess of 50 per cent. of the cases, and certainly greatly over 50 per cent. if we omit cancers of the skin. When one takes into consideration the fact that of every 8 deaths 1 is from cancer, and the additional fact that it is unquestionably on a steadily progressive increase, as is shown by records of the older hospitals, and that this increase can be only partially explained by more accurate diagnostic methods, one is indeed impressed with the significance of the cancer problem.

Cancer is always a curable condition for a certain period of its existence, for it is unquestionably very narrowly a local process. Unfortunately, this stage of cancer is devoid of symptoms and signs except when it is very superficial. Contrariwise, after a certain other period of time, variable in different types and different locations, during which the tumor is local, but embraces structures more or less remote from the primary growth, it is regional. In this case the cancer is still curable, if one can be fortunate enough to remove all the cancer-bearing tissue, a possibility that one can never know when one has attained. Or, being regional, a part of the affected tissue may be manifestly unremovable on account of the vital importance of the structures attacked. Later, in the majority of cancers a still more extensive distribution of the growth takes place; it becomes general from a practical, and often enough, indeed, from a literal, viewpoint. Metastases have occurred throughout important organs.

From the standpoint of the cancer type it may be said that the squamous-celled tumors offer the best prognosis. Hence, as an illustration, we may cite cancer of the skin, which is curable in the vast majority of cases if taken in hand at a reasonable time, a factor rendered possible by the superficial site of these growths. The glandular forms are, as a whole, much less amenable to treatment both on account of their nature and their deeper situation. The average life of a patient with the former type of tumor is five to ten years, while that of those who have glandular tumors is from six months to two or three years. Of the glandular type, the greater the supply of connective tissue, the greater the expectancy. Thus the order of death would be, first, in the medullary or encephaloid type, in which in the acute forms the growth may be so rapid as to be mistaken for an inflammatory process, and occurs early, in six to twelve months; second, from the simple form in which the stroma and parenchyma are about equally abundant, and which produces death in from eighteen months to three years; third, the scirrhous type, which kills in from five to fifteen years.

Cancer kills its host in various ways: First, of course, it may and will kill, barring accidents and complications, by exhaustion, anemia, and cachexia. Second, it may kill its host suddenly or by degrees by hemorrhage. This may be the cause of sudden death in cancers of the uterus, stomach, rectum, or bladder, but repeated hemorrhages of varying degree are more common by far than fatal hemorrhages. Cancers do not bleed into the tumor substance nearly as frequently as sarcomata do. Third, infection may be mild and contribute only a part, or it may be altogether responsible for the patient's death by the local action of the bacteria or by the causation of a general septic condition. Fourth, the general wasting, in the absence of definite hemorrhage, by the loss of body fluids with more or less admixture of blood, may hasten the end, Fifth, embolism may be the cause of sudden death, and is more especially likely to occur in the advanced, inoperable cases, especially as a consequence of manipulation or of a palliative operation. The source of the embolus may be either a mass of cancer tissue liberated in a vein, or a blood-clot which has formed either simply on account of blockage of the circulation or by the presence of infection. Thrombosis may be the direct cause of death in cases of cancer, but, as a matter of fact, does not frequently do so. Sixth, various accidents which interfere with normal function may cause death. Cancer of the larynx may cause it by asphyxiation; of the esophagus, cardia, or pylorus, by starvation; of the intestine, by intestinal obstruction, acute or chronic; of the rectum, by autotoxemia from fecal retention; of the liver, by blockage of the bile-channels, which produces cholemia, or by destruction of the portal circulation, which results in inanition and ascites.

Acute or encephaloid cancer, growing rapidly in a young patient, in general offers a very poor prognosis.

The prognosis of skin cancer is better than that appearing in any other structure, and if the cases are treated according to the most approved methods and are taken in charge at a reasonable time, they would give a percentage of cures approximating or possibly exceeding 90 per cent. Cancer of the tongue should likewise give usually a high percentage of cures on account of the ease of early recognition, but, as a matter of fact, cures are exceptional because patients who have cancer of the tongue usually stubbornly resist proper treatment until they have advanced to a hopeless stage. Early radical treatment shows very satisfactory results. Cancer of the breast, as the cases (operable) come, have in the best records a percentage of cures approximating 50 per cent. On the average, from combined statistics, its percentage would fall considerably below this maximum. Cancer of the stomach is exceedingly unfavorable in its outlook. The usual stage of advancement and the impossibility of making satisfactory clinical diagnosis militate against a satisfactory opportunity to do promising work in this condition. The number of cures varies very materially in different reports and on account of the part of the stomach affected. Pyloric cancer is most amenable to surgical treatment (there is no other treatment). The average number of cures beyond the three-year limit ranges probably between 20 and 30 per cent. at the present time, and has been increasing rapidly during the last decade. This promises very favorably for the probability of cure in gastric cancer when we once have learned to advise exploratory incision on grave suspicion and cease to wait for clinical findings to determine the presence of cancer. I would not, however, convey the idea that all clinically recognizable cancers are inoperable or that all those discovered by exploration are operable. The question can be settled only by opening the abdomen and inspecting the field. A moderately high mortality attaches to partial gastrectomy and a very high mortality to complete gastrectomy. Cancer of the uterus presents one of the gloomiest and most disheartening pictures the surgeon has to contemplate; theoretically, looking as if it should promise a rather favorable field for cure, each surgeon's experience, whether large or small, proves it to be one of the very most hopeless of surgical lesions. The ultimate recovery of these cases is covered by something less, probably very much less, than 10 per cent. In reality it is not likely much more than 5 per cent. Late diagnoses are here, too, responsible for somewhat of the small number of cures, but not entirely. No man can say whether a uterine cancer is operable until he has explored the pelvis through an abdominal incision (Wertheim). Cancer of the liver is almost absolutely hopeless; the only type that can possibly become amenable to excision is a single nodule situated near the surface or the margin of the organ. Cancer of the bladder, whether treated by removal, partial resection, or total extirpation, shows permanent cures of 10 per cent. and less, average about 7 per cent. Cancer of the rectum is more fatal both as to operative mortality and recurrence in young patients, *i. e.*, under thirty years of age; both decrease gradually until the age of fifty. Between fifty and sixty years is the period that gives the smallest operative mortality, about 12 per cent., and the smallest percentage of recurrence, 60 per cent. (Tuttle). Cancer of the esophagus may be accepted now as invariably fatal; since the advent of differential pressure methods for intrathoracic surgery there has been considerable effort to perfect a technic for resection of the esophagus, but, while the results are somewhat encouraging, the cases are not sufficiently numerous to offer much hope of recovery.

The remaining sites of cancer are of minor importance, so far as frequency is concerned, as compared with those discussed above; and the factors which influence the prospect have been discussed with sufficient elaborateness to render the reader capable of forming a correct prognosis without discussion in detail.

That spontaneous recovery from cancer has occurred is undoubted, but it is so rare an occurrence that no hope, utterly none, can be offered by the physician. He does his duty when he tells his patient that cancer kills and always kills when left to itself.

The outlook in cancer cases then is gloomy because the cancer is not attacked early enough, and about the only hope at present is to disseminate a correct knowledge of the facts, so that patients will apply on slighter suspicion of disease, and submit to radical procedures on microscopic rather than on clinical evidence.

Treatment.—Treatment is divisible into curative and palliative, applicable respectively to operable and to inoperable cancer. These terms have already been defined under Sarcoma, but repetition is pardonable. An operable cancer is one which offers a possibility of removal of the entire mass of cancer cells and which offers an operative and an ultimate recovery. An inoperable cancer fails in one or both of these respects.

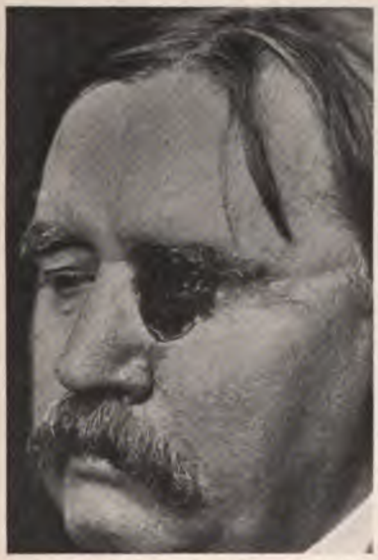

Fig. 210.—Eyelids, eye, orbital tissue, and floor of orbit removed for epithelioma of lower lid. The lower opening is into the antrum and nasal cavity.

The curative treatment of cancer contemplates the complete removal or destruction of the tumor by whatever means it is to be accomplished. So long as a single cancer cell capable of growth and situated favorably remains in the body, the patient is not cured. Since it is impossible to know just how far the growth has extended, it is manifest how one can never be absolutely positive that cancer has been cured. The means employed for the cure of cancer are operation, cauterization, *x*-rays and radium, fulguration and escharotics, or combinations of these.

The *operative treatment* of cancer can be a rational procedure and can offer the best results only when it is based upon an accurate understanding of the behavior of cancerous tissue relative to the normal tissues, especially its capacity to infiltrate, to attack the lymph-nodes either by direct extension or by the escape of cancer cells into the lymph-stream, its metastases, and the capacity of implantation grafts. Certain practical conclusions have been drawn from a just consideration of these factors, and failure to abide by them may result disastrously for the patient. Owing to the tendency to infiltrate, often far beyond the limits of clinical evidence, the first requirement in the excision of cancer is that the incision shall be made relatively wide of the cancer limits and that if possible the organ in which the tumor appears should be excised. This rule is modified by resection of a part of the organ if it is of vital importance and if the tumor is small. The sacrifice of tissue, skin, muscle, bone, whatever it may be, is considered necessary if there is any question of its invasion. Second, the tumor and the lymph-nodes into which it is likely to spread are both to be removed, preferably *en masse*, whether they show signs of enlargement or not. This means not only that nodes and tumors are to be cleared out, but the entire group of nodes and lymph-channels connecting them with the tumor. For if cancer extends its root-like processes along the lymph-channels, to leave them would mean certain recurrence of the tumor.

On account of the possibility of metastasis it is necessary that the tumor shall be handled as gently and manipulated as little as possible prior to and during the operation, and it should also be a rule of common practice to ligate the important vessels which supply the tumor early in the operation, so that if the necessary manipulation should dislodge an embolus it cannot be carried away from its place.

The possibility of implantation grafts serving as the cause of recurrence is not sufficiently impressed. The tumor, the lymph-nodes, all cancer-bearing tissue should be excised, not dug, torn, or curetted out, and the instruments should never come in contact with cancer cells nor the latter be allowed to come in contact with the raw surfaces of the wound. Unquestionable cases of this form of recurrence have been reported, and if the truth were known they would doubtless be much more numerous. If it is necessary to cut into cancerous tissues for microscopic specimens, or if it be done accidentally, the tissues should be guarded from contamination just as assiduously as one would guard the peritoneum against an infected focus. The cut cancer surface should immediately be cauterized with carbolic acid or Harrington's solution and, if possible, closed by sutures.

Illustrative of the operative treatment of cancer two examples will be given, namely, cancer of the breast and of the penis. In cancer of the breast the whole of the organ, a varying area of surrounding skin and fat, the pectoral muscles, and the axillary fat which contains the lymph-nodes, are all to be removed by single block dissection, working preferably from above downward and ligating early the vessels coming downward from the axillary artery. It may be necessary to extend the incision above the clavicle and to remove the supraclavicular fat and nodes. If on removal of this tissue it is found that the tumor has attacked the thoracic wall, it too requires to be resected, preferably under differential pressure. Certain surgeons spare the pectoral muscles, simply cleaning away the lymph-bearing fascia.

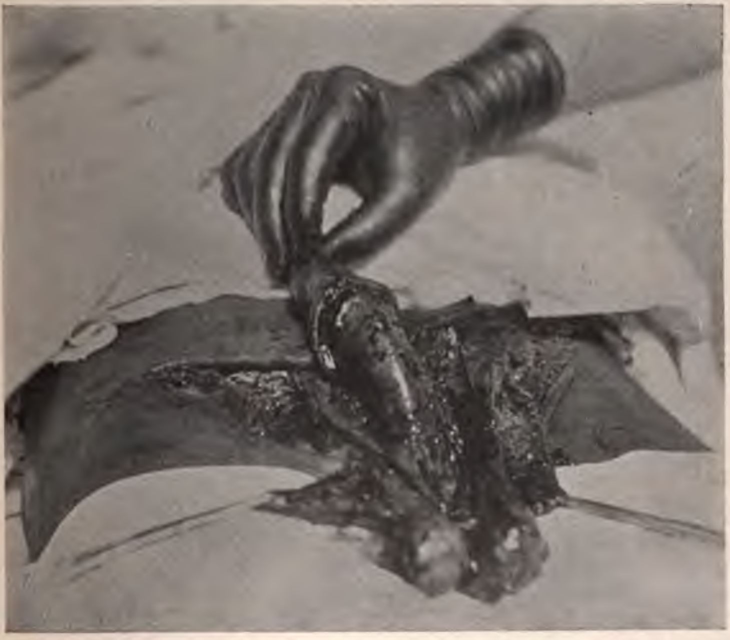

Fig. 211.—Dissection required to remove growth shown in Fig. 179.

If the penis is affected, the whole of the body of the organ back to the osseous attachments, and the lymphatics of the groin with the connecting lymph-channels and connective tissue, must be dissected away in one mass.

From what has already been stated concerning the requirements for the cure of cancer, to the effect that every vestige of the growth must be removed, it is needless to state that by whatever means this end is accomplished, cure will follow. The employment of the actual cautery has been resorted to in the past with considerable frequency for the destruction of cancerous tissue with a view of producing a cure. It is used at the present time for the same purpose, but with much more restriction. The devious paths of infiltration and the growth of the cancer mass in slender processes along the lymph-channels would teach the danger of leaving unharmed portions of the tumor *in situ* to continue its growth perhaps even with increased vigor. Naturally, this plan of treatment is feasible only in cancers of the skin, possibly also of the mucous membrane of the mouth. And if one can be sure that no widespread infiltration has occurred and that no invasion of the regional lymph-nodes has taken place, that is, if the tumor is confined to narrow superficial limits, it cannot be doubted that cure may be obtained in this way. The greater field that may be covered by careful dissection, and the more definite accuracy with which diseased or suspected tissues may be removed without harm to the related structures, have led the majority of surgeons to abandon the actual cautery in favor of the scalpel. When cauterization is chosen as the most suitable agent, it should be done with an instrument heated to a dull-red ("cherry") hue, so as to

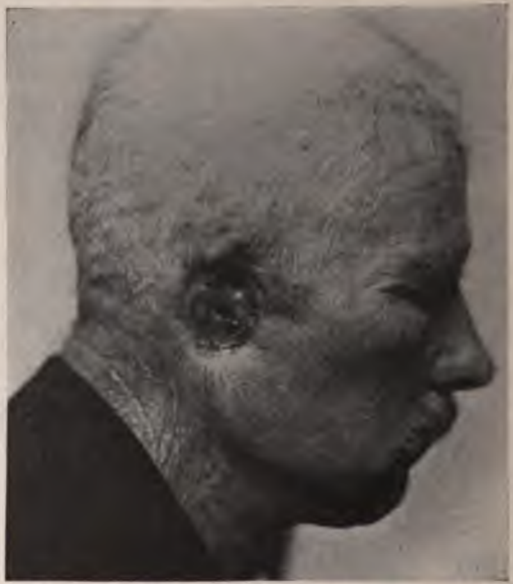

Fig. 212.—Showing result of removal of right ear, parotid gland, and the surrounding skin for a large epithelioma of lower half of ear. Treated with *x*-rays immediately after operation.

accomplish hemostasis at the same time. The tissues should be cauterized for some distance in every direction from the tumor mass. There is no doubt that cauterization properly done is a much more satisfactory plan than the next to be discussed, namely, escharotics; however, it is accepted now-a-days usually as an adjuvant to be employed as a preliminary step and to be followed up by some more reliable agent. The value of cauterization in the treatment of inoperable cancer and for relief of certain complications will be discussed later.

Similarly to cauterization, escharotic drugs (potential cautery) are employed occasionally for the removal of cancer, again superficial. They were formerly employed very extensively, but are now left as the remedy of choice to that vampire of modern medicine, the cancer quack. The same rule obtains in this as in cauterization, viz., if all the tumor cells are destroyed, cure results; and if not, no cure follows. The selective action of escharotics for cancerous tissue in preference to adjacent normal tissue I have not been able to see verified, although I have had the privilege of examining many such specimens. The tissues are destroyed *in toto* to a certain depth and the eschar is thrown off by the healing process. The drugs used by preference are some preparation of arsenic, especially arsenious acid or the chlorid of zinc. The most popular formulas employed were known as Vienna paste and London paste. There is no doubt that many cures have been produced by these drugs; there is less doubt that unnumbered hosts have gone to their graves because this line of treatment was given preference over unquestionably more efficient plans.

The discovery of *x*-rays brought into the therapeutics of cancer the most astonishing and satisfactory remedy that the profession has yet known. The dangers of this form of electricity to both patient and physician cannot be entered into in this connection. Suffice it to say that the first lesson to be learned in reference to this plan is that the treatment of any lesion by *x*-rays should be left entirely in the hands of those who are skilful in their use and who have had sufficient experience to escape the serious blunders that may befall the novice. It is needful also to emphasize the fact that *x*-rays are not a panacea for cancer. The number of cancers amenable to this treatment is comparatively limited, embracing only those which appear on the skin or the easily accessible mucous membranes, as in the mouth; nor is it, indeed, capable of cure in all of these. The deeper tumors are not curable by this treatment, and in a general way cancer of the mucous membrane is much less susceptible to it than cancer of the skin. The denser the tissue to be penetrated by the rays before reaching the cancer cells, and the thicker the tissue lying between them and the surface, the less efficiently do the rays destroy them. Hence, the most adaptable field for the employment of x-rays as a cure is in thin superficial cancers. Deception of both patient and physician often occurred while the profession was learning this lesson, for the ulcerating surface of a cancer may be made to heal almost like a wound healing by second intention, while the deeper portions of the tumor are retarded little if any by the attenuated rays that chance to reach them. Therefore, in all cases of deep cancer no attempt need be made to produce a cure, whether the cancer originated deeply, or has by infiltration, metastasis, or lymphatic involvement grown deeply into the tissues. It is all one; the rays do not penetrate the tissues sufficiently to kill the growth, although they may retard it. Another feature of x-ray treatment of cancer is the influence it has in alleviating pain, even in inoperable, incurable cases. Inoperable cancers are sometimes materially reduced in size and retarded in growth by x-rays. Radium and Finsen rays are employed in a manner similar to that of x-rays and with fairly good results, although the latter treatment is almost universally used to the exclusion of the former two.

Fulguration is a plan of electric treatment devised by de Keating-Hart, of Paris. This treatment is still in its infancy, having been first published about five years ago, but the results so far reported by him would indicate that it is a valuable adjunct to the treatment of cancer. It must be emphasized, too, that it is curative only when the macroscopic tumor mass has been removed by excision. Even when complete removal of the tumor is impossible, this treatment renders service by relieving pain, by control of hemorrhage, and other troublesome or dangerous complications. de Keating-Hart advocates thorough removal of the tumor and immediate fulguration of the wound, and claims and apparently proves that recurrence will be less frequent or longer delayed, that many can be cured by this plan who would fail to be cured (who have indeed failed) by other plans, and that considerably longer expectancy can be offered in many hopeless cases. The time of treatment averages about one minute per square centimeter. Anesthesia is imperative.

The ideal treatment in many cases of cancer is a combination of two of these methods. In those cases which are pre-eminently amenable to x-rays, but in which the mass of tumor tissue is so great as to offer a possible prevention of cure, it is absolutely necessary that the tumor shall be removed by excision or destroyed by the actual cautery prior to beginning the x-ray treatments. In such cases the wound should, when it is at all feasible, be permitted to remain open, so that direct exposure of any residual cancer cells may be obtained. In those cases in which the treatment is *par excellence* operative, it is a wise plan to expose the field to *x*-rays to produce a redoubled assurance that no vestige of cancerous tissue shall escape. This may be done prior to closure of the wound or subsequent to healing. The former plan is impracticable in the majority of cases, and unless the tumor is situated near the surface of the body, as, for example, in the breast or the penis, no benefit can be hoped for. The indications at the present time are that fulguration is also a very valuable adjunct to operative treatment. It is to be employed at the completion of operation, while the patient is still anesthetized.

Treatment of Inoperable Cancer.—The physician must not lose sight of the fact that his services may be of untold value in cases of incurable cancer. The demand for such treatment is for the accomplishment of one or more of the following ends: To prolong the life of the patient as much as possible; to relieve pain and discomfort; to re-establish the possibility of necessary function, which has been interrupted by the presence of tumor; to control hemorrhage; to prevent or correct decomposition and the attendant stench, ulceration, and inflammation.

By attending carefully to two factors, namely, to maintain nutrition and to prevent depletion, much may be done to prolong the life of cancer patients. Especially is this to be accomplished by pursuance of the instructions which follow, and by the employment of those agencies which retard the growth, whether operation, *x*-rays, radium, or fulguration.

Pain, when present in cancer, is often excruciating. The first requisite is to decide whether the pain arises from the cancer itself or from a complication. If the cancer itself is producing the pain the first idea should be to relieve it, if possible, by the resection or avulsion of the sensory nerves supplying it. This can be done with greatest satisfaction in cancer of the mouth or tongue. If pain be due to some complicating factor, correction of this factor may be possible and safe, and its performance should be demanded even though it will not prolong life. In all cases where pain is present *x*-rays should be thoroughly tried, for it is perhaps the most potent agent we have for satisfactory relief of pain, and at the same time tends to retard the growth and often even to reduce the size of the tumor. It is useless to expect *x*-rays to relieve the pain produced by obstruction and similar complications. If the pain cannot be relieved by the above or other agencies at hand, the patient should, as much as possible, be made comfortable by the administration of anodynes and narcotics, of which, of course, morphin stands at the head of the list. Of all cases, the physician is excusable for administering morphin for the few days that remain to the patient who has incurable cancer.

The life of incurable cancer patients can very frequently be prolonged by relief of complications which interfere with nutrition or elimination, and at the same time much unnecessary discomfort be removed or avoided. In this way the patient who has cancer of the esophagus may be treated by gastrostomy; cancer of the larynx, by tracheotomy; of the pylorus, by gastroenterostomy; of the small intestine, by entero-enterostomy or resection; of the cecum, by enterocolostomy; of the rectum, by colostomy; of the prostate or bladder, by cystotomy.

Control of hemorrhage in cancer is frequently the greatest burden of the physician. It is unnecessary to mention the ordinary plans of hemostasis in general use. They are of service here as elsewhere, but the conditions are different, and the hemorrhage controlled to-day, to-morrow recurs and may result fatally. The prevention of ulceration and necrosis is of prime importance in the avoidance of cancer hemorrhage; but often these cannot be prevented long. Two plans are especially applicable for this purpose, provided the general condition of the patient will permit them, namely, ligature of the blood-vessels supplying the tumor, or removal of the entire growth, if this can be done more safely and more effectively than ligation in continuity. The superiority of removal over ligation lies in the fact that in the former collateral circulation will not re-establish the hemorrhage. Hemorrhage may often be controlled by removal or destruction of the decomposing portions of the tumor, as in cauterization, curetment, or the application of acetone in cancer of the cervix uteri.

Infection, ulceration, decomposition, and inflammation are partially amenable to the same plans here as elsewhere. I say partially, because the important factor of resistance on the part of the living tissues to such influences is either wanting or reduced to a very low state. Cleanliness, the employment of antiseptics and deodorants are the plans upon which we must rely. It is only by untiring efforts that even a modicum of relief can be secured in many cases.

CHAPTER XLVII

CYSTS

Definition.—A cyst may be defined as a closed sac filled with a fluid, semifluid, or caseous substance. The sac may be a vestige remaining from unobliterated embryonic structures, anatomically normal or adventitious.

Structure.—The structure of cysts is very simple. In those which form in normal anatomic spaces the sac is unchanged, except in so far as distention and the formation of new connective tissue added to its outer surface cause an increase in its thickness. In the new-formed cysts the sac is made up of connective tissue. Those cysts arising from tumors are peculiar in this respect, namely, that they have a wall lined with one or more layers of tumor cells, the adenocystomata having a distinct capsule, which serves at the same time as the fibrous portion of the sac, and cystic sarcomata which have no such capsule, the tumor cells alone forming a limiting wall to the fluid contents.

Cysts are unilocular, having a single cavity, or multilocular, having more than one cavity; often these cavities are numerous. In multilocular cysts the septa separating the various cavities are constructed of the same material as the sac.

The lining of cyst cavities may be simply the normal epithelial or endothelial cells found in the normal structure from which the cyst arises. These cells may continuously cover the interior surface of the sac or only partially cover it, having been separated by excessive distention. In other instances, namely, in cysts of new formation, there may or may not be a cellular lining.

Contents.—The contents of cysts vary so widely that they can be discussed adequately only in connection with the various cysts as they are taken up seriatim. These contents are derived either from the lining of the cyst, from some connected normal structure, or from some accidental source, as in case of hemorrhage or necrosis.

Characteristics.—The general characteristics of cysts are to be summed up in the statement that they are such as would be produced by any well-defined sac located within the tissues, namely, as a movable, soft, boggy, or fluctuating mass. They are well defined in outline, much as encapsulated tumors. Cysts usually grow more or less in a spheric shape unless influenced by the surrounding structures. Aspiration of cystic cavities usually reveals the presence of the characteristic contents of the special cyst in question. This statement is not intended as a recommendation to employ aspiration as a routine diagnostic measure. The habitual sites of formation of cysts adds much to the facility of reaching an accurate diagnosis. The rule is that cysts are tightly distended by their contents, although they are sometimes flaccid. The cyst wall, instead of being thinned by distention, is often thickened by a heavy deposit of connective tissue.

Complications.—Cysts are subject to few complications. They, of course, may become inflamed and rendered thereby more tense and larger, and accompanied with the usual local and general symptoms of inflammation. Necrosis or rupture of the cyst rarely occurs. If pus forms, the contents of the cyst are modified accordingly.

Classification.—I. Retention cysts.
    1. Sebaceous.
    2. Mucous.
    3. Cysts of glands and their ducts.
        (*a*) Kidney—hydronephrosis.
        (*b*) Gall-bladder.
        (*c*) Pancreas.
        (*d*) Salivary glands and ducts.
        (*e*) Vulvovaginal glands.
        (*f*) Breast.
        (*g*) Meibomian glands, Chalazion.
        (*h*) Sudamina.
        (*i*) Lymphatic.
        (*k*) Chyle cysts.
        (*l*) Nabothian cysts.
II. Exudation cysts.
    1. Hydrocele.
    2. Bursal cysts.
        (*a*) Miners' elbow.
        (*b*) Weavers' bottom.
        (*c*) Housemaids' knee.
        (*d*) Boyer's cyst.
    3. Hydrothorax, ascites, and hydropericardium—not classed as conventional cysts.
III. Extravasation cysts.

- IV. Embryonal cysts.
    - 1. Thyroglossal or thyrolingual.
    - 2. Branchial.
    - 3. Urachal.
    - 4. Hydrocele of the cord.
    - 5. Sequestration.
    - 6. Urogenital.
    - 7. Vitello-intestinal.
    - 8. Kidney and liver.
    - 9. Cholesteatoma.
    - 10. Dentigerous.
- V. Cysts of new formation.
    - 1. Of soft parts—hemorrhagic.
    - 2. Of bones.
    - 3. Of tumors.
        - (*a*) Cystadenoma.
            - (1) Mammary.
            - (2) Ovarian.
        - (*b*) Of sarcomata.
    - 4. Necrotic.
- VI. Parasitic cysts.
    - 1. Echinococcus.
    - 2. Cysticercus cellulosæ.
- VII. Dermoids.
- VIII. Traumatic inclusion.

Retention Cysts.—A retention cyst is one which forms in consequence of obstruction to the outflow of secretions or other body fluids and their consequent accumulation and distention of the ducts or glands.

Cause.—The cause of such obstruction may be very varied, one or more causes pertaining to one type of cyst, while another type may be produced by very different causes. The usual obstructions are cicatrices or strictures, foreign bodies, such as calculi in the lumen of the duct, tumors pressing upon and collapsing the duct or invading and blocking it, and torsion of the duct.

Sebaceous Cysts.—Sebaceous cysts, or atheromata, are due to the blockage of the sebaceous glands of the skin, and consequently do not occur on those surfaces of the body which have no sebaceous glands, namely, on the palms and soles. They may occur on any other part of the cutaneous surface, but are far more frequently found on the face, scalp, neck, shoulders, back, and scrotum. They are produced by the formation of comedones in the mouths of the glands or by cicatrization at the mouth of a sebaceous gland; the former is the more frequent cause. Paradoxically the site of most common formation of comedones is rarely affected by sebaceous cysts, owing to the dense connective tissue in which the glands lie.

The contents of sebaceous cysts are a dirty, grayish-looking, caseous residue of the secreted sebum. Sometimes the employment of pressure will dislodge the comedo and allow the evacuation of the cyst contents through the mouth of the gland in a worm-like thread. Sebaceous cysts may be single or multiple, occasionally numerous. They are usually small, although one occasionally sees one the size of a hen's egg, rarely as large as a tangerine orange. They grow rather in a spheric shape when large, but the smaller ones may be either spheric or of a flattened saucer shape. They have a boggy feel, the larger ones often being pseudofluctuant. They originate in the skin, and, while they are distinctly movable over the remainder of their surface, a point of attachment can usually be discovered. Their surface is smooth and they are elevated, tumor-like, above the surrounding skin level. In the scrotum the coverings may be so thin as to show the whiteness of the contents distinctly.

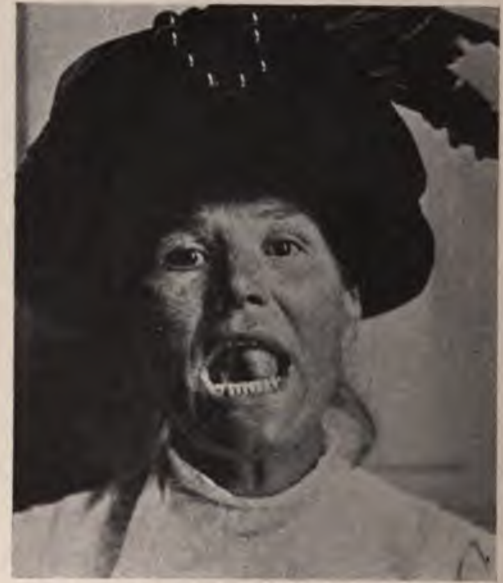

Fig. 213.—Cyst occurring in tongue of a woman.

Sebaceous cysts cause no pain and do not endanger life. They sometimes become inflamed and may suppurate, resembling somewhat an acute furuncle, from which they can be distinguished by the comedo, the history of a swelling prior to the appearance of inflammation, by the contents of pus and caseous material, and by the absence of a core. When inflamed cysts are treated as an abscess they recur, unless the inflammatory process has been severe enough to destroy the lining of the sac.

Treatment.—Sebaceous cysts are treated by total excision of the sac, preferably without opening it. If the sac is accidentally opened the utmost care should be employed to remove every vestige of it to prevent return of the cyst. Expulsion of the contents is a worthless procedure. If for any reason the sac cannot be dissected out, or if it is deemed advisable not to attempt dissection, the lining should be thoroughly cauterized with pure carbolic acid or otherwise, packed, and allowed to heal from the bottom.

Mucous Cysts.—Mucous cysts sustain the same relation to the mucous glands that sebaceous cysts do to the sebaceous glands. Mucous cysts occur as a consequence of blockage or obliteration of the mouths of the glands by cicatrices. They are found especially in the lining of the mouth and on the tongue, occasionally they appear in the vagina; Nabothian cysts are of this type. They are usually small, rarely attaining the size of a chestnut. They are fluctuant and translucent. Aspiration procures a thin, ropy, mucoid fluid. They may form much more rapidly than sebaceous cysts.

Treatment.—The treatment consists in excision, preferably followed by suture. Where this is not feasible, the sac may be slit open and the lining cauterized or otherwise destroyed and the cavity allowed to heal from the bottom.

Duct Cysts.—Among the cysts forming in the glands or the ducts affording an outlet to them the usual ones are those of the salivary glands, the gall-bladder, the pancreas, the kidneys, and the vulvovaginal glands. In any of these the causative agent is mechanical obstruction to the duct, namely, stones, scars, strictures, torsion, tumors within or without the duct. In the salivary glands the common cause is a stone within the duct of the parotid and of the submaxillary glands. The obstruction of Rivini's ducts, on the contrary, is cicatricial. The other possible causes, excepting torsion, may apply here. Obstruction of Stenson's duct may cause cystic dilatation of the duct or of the gland; while obstruction in Wharton's duct causes distention of the submaxillary gland owing to the rigidity of the duct. Obstruction to Rivini's ducts causes distention of the ducts and produces a sublingual cyst known as ranula.

Cysts of the parotid gland, Stenson's duct, and the submaxillary gland fluctuate in size if the obstruction is incomplete, becoming larger when salivary secretion is stimulated during the ingestion of food or acids. The recognition of these cysts is easy when the anatomic site of the structures containing them is considered. They have the usual characteristics of cysts. In Stenson's and Wharton's ducts the site and often the nature of the obstruction can be determined by probing the duct, while a ranula appears as a round translucent sublingual mass. Sometimes when a calculus causes the obstruction to Stenson's or Wharton's duct, it can be palpated. Naturally no discharge escapes from the mouth of the completely obstructed duct.

Treatment.—Treatment consists in the removal of the obstruction if possible. If a stone is present it may be gradually forced down to the opening into the mouth and removed by slitting the mouth of the duct, if necessary, or by incision of the duct. Strictures may be dilated by the usual method unless they are densely closed. If the duct cannot be reopened, a new opening must be established with or without excision of the cyst. In no instance should the mistake be made of opening such a cyst (especially of Stenson's duct) from the skin surface, as it will establish a very annoying fistula. This new opening may be made according to Agnew's plan, if the cyst is close enough to the mucous lining of the mouth, by transplanting the duct and making a shorter route, or by doing a plastic operation for reconstruction of the duct. When these plans fail the only hope lies in excision of the gland. A cystic submaxillary gland offers only the alternatives of removing the obstruction and excision of the gland.

Ranula is treated by preference by Agnew's plan. A needle threaded with coarse linen or silk is passed from the mucous membrane of the mouth into the cyst cavity and out again and tied loosely. This ligature gradually cuts its way out and re-establishes the opening. If this plan fails, the button-hole operation may be done. As a last resort excision of the gland and cyst is done.

Hydronephrosis is usually caused by stone in the ureter, by kinking or torsion of the ureter, or by accidental ligation. Other causes sometimes produce it.

The treatment of hydronephrosis demands removal of the cause, nephrotomy if a stone in the ureter, fixation of the kidney if torsion is the cause, or nephrectomy if the kidney is hopelessly damaged.

The remaining types of cystic kidney will be discussed in connection with cysts of new formation.

Cystic gall-bladder is generally produced by blockage of the cystic duct by gall-stones or by cancerous obstruction of the cystic or the common duct. In the event that the cystic duct is blocked the fluid is usually clear, with the possibility of an admixture of bile; if the common duct is obstructed bile may fill the distended gall-bladder. Cystic gall-bladder may be relieved by removal of the obstruction or by excision of the gall-bladder, dependent upon the site and nature of the obstruction.

Obstruction to the pancreatic ducts is due to stones, tumors, cicatrices. Pancreatic cysts of the retention type contain pancreatic fluid. It must not be imagined that pancreatic cysts are all of the retention type. Others of obscure origin are found.

Pancreatic cysts are treated by excision or by marsupialization and drainage. Fistulæ are likely to persist for a long time after the latter plan. In cases of cure the unfortunate sequela of diabetes mellitus has sometimes been observed.

Cysts of the vulvovaginal glands follow usually upon suppurative processes in them, which, in their turn, are commonly due to gonorrhea.

The treatment is excision and suture, or by the open method.

Chalazion is a retention cyst of the Meibomian glands, and appears as a small round pea-like body in the upper eyelid. They are often multiple.

The treatment consists in eversion of the lid, incision through the mucous membrane into the cyst in a line parallel to the normal direction of the Meibomian glands, and thorough curettage of the lining membrane, which must be completely destroyed to prevent recurrence.

Retention cysts of the breast are of several forms:

First, a chronic mastitis may result in the formation of innumerable small cysts in one or both breasts and cause marked enlargement of the organ. The condition is known as cystic disease of the breast. The cysts are small, averaging about the size of a pea.

The second form is that in which a tumor has formed, blocked the outlet, and caused the dilatation of a milk-duct. The tumor may be found within the cavity of the cyst. The tumor, therefore, appears as an intracanalicular growth.

The third form of retention cyst of the breast is the involution cyst. The cysts are usually multiple, of small size, and filled with fluid which may resemble milk, or be of a serous or colloid appearance. It is often brownish or greenish in color, and rarely is caseous.

Obstruction to the outflow of milk may result in large cysts which are termed galactocele.

The treatment of retention cysts of the breast is either excision of the cyst or, if they are numerous and cause annoyance or disfigurement, amputation of the breast.

Lymphatic and Chyle Cysts.—These cysts are of questionable origin, and might perhaps more appropriately, so far as their origin is concerned, be discussed in connection with lymphangiomata or, better still, be described as an ultimate outcome of lymphangiectases. The fact remains, however, that they obtain their origin as cysts by the retention of the lymph in the dilated lymphatics, and as the distention continues all avenues of entrance and exit from the cystic cavity are closed and the lining endothelial cells assume a secretive action. They are most common in the neck, where they are known as congenital cystic hygroma, and appear as moderate or enormous enlargements in the newborn and show the common characteristics of cysts. They are translucent if the fluid is clear serum; but it may be milky or chocolate colored, and translucency is wanting in these. They are multilocular cysts and often extend down among the structures of the neck, so that removal *in toto* is out of the question. These cysts may disappear spontaneously as the child develops, or may require dissection, which gives satisfactory results even when the whole cyst cannot be removed.

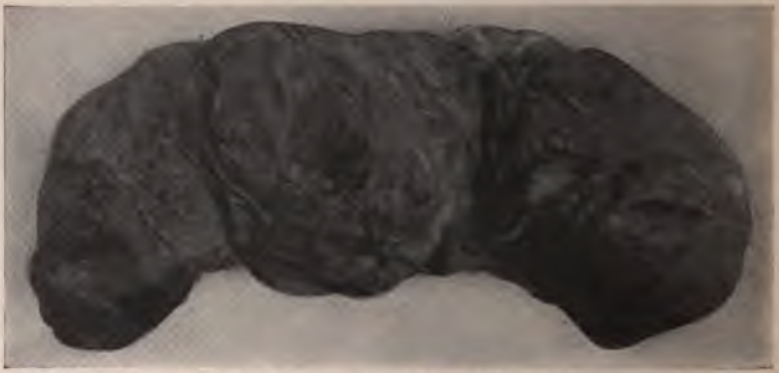

Fig. 214.—Large hydrocele in tunic, the neck of which was unobliterated. The constriction at the left lay within the deep ring.

Similar cysts appear in the mesentery and contain chyle, and are known as mesenteric chyle cysts. They are not congenital in origin and probably result from obstructions occurring at the time of their origin. Such cysts have rarely been reported as interfering with delivery of pregnant women.

The treatment is removal, complete or partial, as circumstances demand.

A retention cyst known as spermatocele forms in the epididymis and may reach the size of an orange. It contains semen or altered semen, and is lined with ciliated epithelium.

Treatment is enucleation.

Exudation Cysts.—This group of cysts forms in pre-existing closed cavities lined with endothelium and capable of a normal secretory function. The action of traumatism, irritation, and inflammation may cause an increase in the quantity of the secretion, which, if it is maintained, results in the formation of exudation cysts.

The form of exudation cyst by far the most common is *hydrocele*, an accumulation of fluid in the tunica vaginalis testis. The fluid is sometimes discolored to a reddish or brownish color or contains blood in old cases of hydrocele with large sacs. The sac itself is usually the distended tunic, a simple sac. If a plastic inflammation preceded the hydrocele, however, the parietal and visceral tunics may have adhered, and the distention resulting from the accumulating fluid produce septa which divide the cavity more or less completely into compartments. The shape of the mass, being larger above than below, fluctuation, the history of the cause, translucency and the recovery of fluid on aspiration are the chief diagnostic features. The quantity of fluid may be as much as a quart. Similarly, but much less frequently, a hydrocele may form in the canal of Nuck in females.

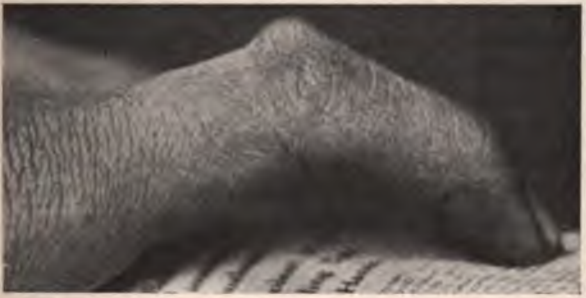

Fig. 215.—Small exudation cyst of index-finger.

Treatment.—The treatment of hydrocele is palliative or curative. The former plan simply contemplates temporary relief from the dragging weight by aspiration. Curative treatment contemplates destruction of the lining secreting endothelium or removal of the sac. This may be done by the injection of 30 to 60 minims of pure carbolic acid after withdrawal of the fluid, followed immediately by massage to bring the acid into contact with the whole lining, after which it is to be washed out with normal salt solution to prevent necrosis or systemic poisoning. If the fluid reaccumulates, as it often does, it should be aspirated again at the end of a week. This method cures about 90 per cent. of the cases when properly done, but fails in the long-standing cases of hydrocele with a thick sac. In the second plan (Volkmann), one buttonholes the sac and sutures the skin to the serous membrane. The cavity is then packed with gauze and caused to heal from the bottom. The third plan (Jaboulay) slits the sac and turns it inside out, placing the endothelial cells in contact with the raw inner surface of the scrotum. The sac may be completely cut away if necessary (von Bergmann).

The exudation cysts second in frequency are those that form in the various bursæ of the body. Their position and the common characteristics of a cyst are sufficient to distinguish them from other lesions.

Four exudation cysts deserve especial mention, inasmuch as they have received special names. They are as follows:

Miners' elbow is an exudation cyst which forms in the bursæ overlying the olecranon process in consequence of the repeated traumatism to the elbow of miners. Housemaids' knee is an exudation cyst of the prepatellar bursæ. It obtains the name from its frequent occurrence in housemaids, whose occupation, as originally followed, caused irritation of this bursa. Weavers' bottom is a third example of this cyst, which is produced by occupation; it forms over the tuber ischii. Boyer's cyst is an exudation cyst of the subhyoid bursa.

Treatment.—The treatment of exudation cysts consists in either removal of the sac *in toto*, or, if this is impossible, destruction of the lining by the methods already mentioned in connection with hydrocele.

Hydrothorax and ascites are pathologically identical with exudation cysts, but are not so classed in the literature.

Extravasation Cysts.—This group of cysts depends for its existence upon the fact that they are due to the escape of blood into the space they occupy. They may, therefore, be of the retention or the exudation type or may be cysts of new formation; in the latter instance the sac forms about the extravasated blood.

Occasionally numerous exudation cysts form in the vesicles of the thyroid gland, constituting one form of cystic goiter. The ovaries may also be the site of similar cysts, of which there are two types, namely, cysts of the corpora lutea and cysts of the Graaffian follicles. The former really belongs to the hemorrhagic cysts. The Graaffian follicular cysts are multiple, small, and harmless.

Embryonal Cysts.—This group depends upon the presence of unobliterated fetal spaces or canals, which remain as persistent parts in the fully developed individual. These spaces were originally lined with epithelium, consequently the cysts have normally a cellular lining. The most important of this group are the thyroglossal cysts, branchial cysts, cysts of the urachus, hydrocele of the cord, non-traumatic (fetal) inclusion cysts, cysts of the Wolffian bodies, and vitello-intestinal cysts.

Thyroglossal cysts occur in the unobliterated portion of the thyroglossal or thyrolingual duct. They appear in the median line of the neck anteriorly above the thyroid gland and below the foramen cecum. Branchial cysts are due to cystic destruction of unobliterated branchial clefts, forming only in the second and last cleft; they may form laterally under the tongue, or in the neck at any point from the angle of the jaw to the sternum. These cysts contain a fluid or caseous material. When the content is fluid, it is due to the derivation of the cyst from the inner or mucous end of the cleft, and is mucoid. When the outer or cutaneous end produces the secretion, it is caseous. These cysts give rise to no little trouble from a diagnostic standpoint and can be recognized often only by eliminating other swellings of the neck. If they are opened they give rise to persistent and troublesome fistulæ.

Cysts of the urachus are extremely rare. They appear in the anterior wall of the abdomen—*i. e.*, anterior to the peritoneum—and may reach an enormous size. They must be distinguished from distended bladder and all forms of cysts occurring in the lower half of the abdomen.

Hydrocele of the cord is produced by causes similar to those producing true hydrocele in a peritoneal pouch which has failed to be obliterated; closure occurs above and below, the sac remains between.

Sequestration cysts are formed in consequence of fetal maldevelopment in which portions of the skin are separated and enclosed in the subcutaneous structures. They usually lie superficially, but may be buried rather deeply in the tissues. These cysts occur in the median line of the body and at the points where the fetal clefts exist. They are lined with true skin, which often contains hairs attached or detached, and are filled with either a caseous substance or a viscid fluid. Sequestration cysts are found most frequently in the region overlying the coccyx, where one may often discover blind pockets leading upward beneath the skin. These not infrequently lead into a sequestration cyst, which, if it becomes inflamed or discharges fluids from the opening, is sometimes mistaken for fistula *in ano*, unless a careful examination be made.

Cysts forming in the remains of the fetal urogenital apparatus are rather frequent. They may form in the Wolffian body, the organ of Rosenmüller, or in Gärtner's duct. Those which develop in the outer tubes of the organ of Rosenmüller are, as a rule, small and give rise to no disturbance. On the other hand, enormous cysts may form from the vertical tubes. Cysts of the Wolffian body often contain papillomata. They are usually multilocular and tend to extend downward in the broad ligament. They occur usually in adults. These cysts all form in the broad ligament or in connection with it. The cysts which arise from Gärtner's duct occur either in the broad ligament between the ovary and the uterus and produce only small cysts, or in the vaginal wall laterally, and here are usually solitary and small, or they may be multiple and arranged in chains.

Vitello-intestinal cysts are found at the navel, where they may appear as a mass, project outward, or be concealed beneath the abdominal wall as extraperitoneal cysts. They form in the unobliterated remains of the omphalomesenteric duct.

Congenital cystic kidney is a very interesting pathologic lesion. The kidneys of the fetus may be so large at birth as to interfere materially with labor, or produce death of the baby soon after labor. In other instances they are only discovered after the patient has reached the adult state. It is a bilateral condition, a fact to be remembered when surgical treatment is contemplated. The kidneys are made up of innumerable cysts of varying sizes, and the condition is thought to be due to an arrest of development during the fetal state. The kidneys may attain the enormous size of a child's head in extreme cases. Patients who have congenital cystic kidneys may occasionally live to be old and die suddenly of uremia. The condition is often associated with a cystic liver and rarely also with a cystic pancreas.

Cholesteatoma is classified by some authors as an endothelial tumor, by others as a form of cyst originating from cells which have been displaced from their cutaneous attachments during development, by invasion of epithelial cells into unnatural positions during disease, as occurs in extension of the skin cells into the tympanic cavity following otitis, or by metaplasia of the cells. Structurally and developmentally cholesteatoma is unquestionably a cyst. The cyst wall is a fibrous capsule lined with stratified epithelium, and in rare instances, even when in the pia, may contain hair, together with sebaceous and sweat-glands. The contents consist of a solid pearly gray or white substance containing large quantities of fatty substances and cholesterin. Cholesteatomata are small, rarely becoming larger than a Japanese plum, but by virtue of their predilection for the temporal bone, especially the middle ear, the mastoid, and the pia mater, may cause grave symptoms from pressure. They grow slowly, but when they are situated within bone cause atrophy or necrosis, rupturing, for instance, from the mastoid either toward the scalp or the dura. They are occasionally found in the urethra.

Treatment.—The treatment for all the group of embryonal cysts consists in removal, with the exception of those appearing in the liver and the kidneys, where radical procedures are contraindicated.

Dentigerous Cysts.—Numerous maldevelopments occur in connection with the teeth, which pass under the name of odontomata and dentigerous cysts. Both conditions are due to perverted development of the teeth or the structures entering into their formation. Odontomata in the vast majority of cases are not true tumors, as their name would imply, hence the failure to discuss them in connection with tumors. It is, practically, unwise to separate odontomata from dentigerous cysts; therefore a brief discussion of both conditions will be given in this connection.

Bland-Sutton's classification of odontomata is as follows:

"1. Epithelial odontoma, from the enamel organ.
2. Follicular odontoma,
3. Fibrous odontoma, } from the tooth-
4. Cementoma, } follicle.
5. Compound follicular odontoma,
6. Radicular odontoma, from the papilla.
7. Composite odontoma, from the whole germ."

Epithelial odontomata arise from the enamel organ and develop as small tumors in connection with the gum of the lower jaw, rarely of the upper, of individuals past middle life. They are rarely larger than a large hazelnut. They are structurally multilocular cysts whose septa are fibrous or perhaps ossified. Bland-Sutton asserts that many of these cysts are, in reality, endotheliomata.

Follicular odontomata constitute the real cystic odontomata or dentigerous cysts. They are ensheathed by a capsule whose thickness varies from that of parchment to ¼ inch or more. This membrane is the outgrowth or overgrowth of the tooth-follicle. The cavity contains a mucoid ropy fluid and the tooth or the remains of one whose eruption failed to occur. Occasionally the tooth entirely fails to develop. These cysts arise in either the upper or the lower jaw and may be bilateral. They usually arise from the permanent tooth-follicles, and among these more frequently from the molars, rarely from supernumerary teeth. The presence of a tumor, the absence of a tooth which has failed to erupt, the benign behavior of the growth, the presence of fluid obtainable on aspiration, and the discovery of the tooth within the sac by puncture with a steel needle confirm the diagnosis. Follicular cysts are likely to be mistaken for sarcomata, but this should not lead to serious errors now as it has done in the past, for no surgeon who cares for his reputation or his patient operates now-a-days for a malignant growth, so long as there is a possibility of error, without first having a microscopic examination. In cases where the cyst arises from supernumerary teeth, of course, no evidence of a missing tooth is at hand. In the majority of cases, in all, in fact, except where no tooth structure is present within the cyst, a skiagraph should reveal the true condition of affairs. The tooth contained in the sac has imperfectly developed, short, stumpy roots.

Fibrous odontomata are derived from the tooth-follicle by the production of a large amount of connective tissue surrounding the tooth. They are very likely to be mistaken for fibromata, until the absence of a normal tooth is observed and its presence within the mass ascertained.

If cement is desposited in the fibrous portion of a fibrous odontoma it becomes solid and rock-like, and is known as a cementoma.

Partial deposits of cement or formation of dentin in the fibrous portion of a fibrous odontoma causes the mass to yield numerous solid bodies resembling teeth more or less completely, and made up of one or all the elements which constitute normal teeth. This is known as compound follicular odontoma.

Radicular odontomata are due to the overgrowth of the root of a tooth after the crown is fully formed. They do not contain cementum.

When the three elements of tooth structure—dentin, cement, and enamel—grow into a bony mass, the resultant tumor is a composite odontoma, which often originates from the formative structures of more than one tooth. It is a rough, hard, irregular bony mass, occurring either in the upper or the lower jaw, especially the latter, in which it may attain considerable size. It is rare.

Treatment.—The treatment of odontomata consists in removal of the pathologic tissue. It is unnecessary to resect the jaw for them, but if they are large it may be necessary to do extensive removal of the deformed portions of bone in order to obtain a shapely jaw.

Cysts of New Formation.—The cysts of new formation not due to parasites are of only moderately frequent occurrence, if we except those that appear in connection with tumors. They are found in the soft parts and in bone. Cysts of new formation are due to hemorrhage, tumors, or necrosis.

Hemorrhagic Cysts.—It is the rule that when hemorrhage occurs into the tissues of the body a hematoma remains for a time and gradually disappears by absorption, leaving no evidence of its former presence except a slight amount of scar tissue. This rule has exceptions: the blood may remain unabsorbed and a sac gradually develop around it, so that it becomes a permanent lesion. The blood-cells, the hemoglobin, and whatever of necrotic tissue may be present are removed and there remains only a clear serous fluid. At first the tissues surrounding the cyst remain more or less discolored, but this discoloration finally disappears and leaves no sign to indicate the true source of the cyst. Naturally, these cysts are largely, though not entirely, due to traumatism. Hemorrhagic cysts are found in goiters, in the brain, the scalp of the newborn, where they are known as cephalematomata, "in the pinnæ of football players and lunatics" (othematoma), and rarely in the spleen.

In the neck a type of blood-cyst is occasionally found which is not due to hemorrhage. They may attain an enormous size, that of a child's head. They may be connected with the veins of the neck and are then reducible in size by continued pressure, or they may have no such connection and be irreducible. The majority belong to the latter class. They have been attributed to cavernous angioma, but their origin is not so well determined as to explain all cases.

Treatment.—The treatment of hemorrhagic cysts is removal. If this cannot be done the cyst may be opened and cauterized or packed, or both, as the case may require. Blood-cysts which are reducible should be dissected out and removed after ligation of their points of connection with the normal vessels.

Cysts in bone are, aside from the so-called dentigerous cysts, exceedingly rare lesions. The majority of them are due to cystic degeneration of solid tumors of bone, especially sarcoma and chondroma, less frequently intra-osseous fibroma, and very rarely metastatic carcinoma. Genuine primary cysts do rarely occur; osteomalacia and arthritis deformans may produce cysts in the bones. Parasitic cysts are rarely observed. The presence of large cysts in bone produces the same symptoms and signs that are observed in tumors of bone. The bone becomes enlarged and the wall may be so thinned as to crepitate. One very important fact to remember is that since bone-cysts are frequently due to changes occurring in a tumor, it is not sufficient to satisfy one's self with the diagnosis of cyst; one must determine microscopically whether the given cyst is associated with sarcoma cells, and the treatment must be directed accordingly.

The treatment of bone-cysts, if they are not sarcomatous, is to open the cyst, clean out the cavity, curet or cauterize, and close the wound. If the bone is extensively destroyed, resection or amputation may be necessary.

Cystic Tumors.—Of this group some give the impression that the lesion is a tumor and the cystic portion a secondary matter; others are so typically cystic that their origin from a previous tumor would never be suspected from a clinical examination of the patient or by the most careful investigation of the gross specimen.

They may be subdivided into two groups, namely, those which result from the action of the cells lining a tumor which has a real or a virtual cavity, cystadenomata, and those due to degenerative changes, found most typically in sarcomata, but also in fibromata, chondromata, and carcinomata. It sometimes happens that a hemorrhagic cyst develops in a soft tumor, just as it does in normal structures.

Cystadenoma.—This is one of the most frequent forms of cyst, and, though it may develop in various structures which produce adenomata, is observed with greatest frequency in the breast and the ovary. If the cells of the tumor secrete a fluid the latter accumulates and distends the cavity.

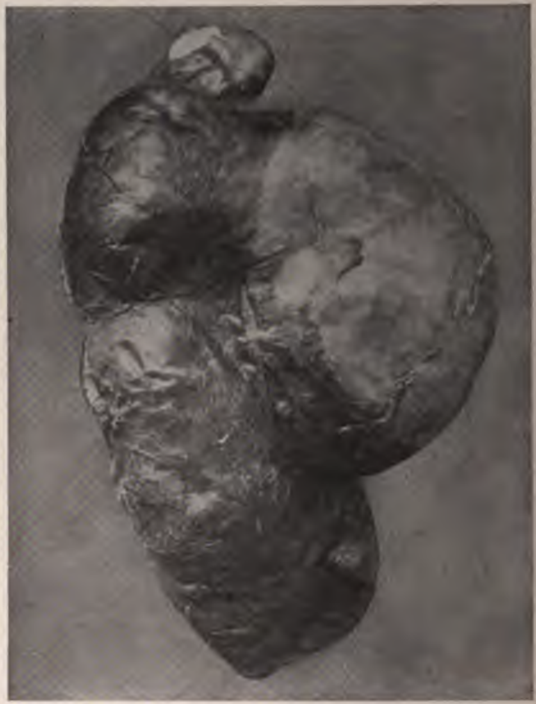
Fig. 216.—Simple cyst of spleen.

Cystadenomata of the ovary are frequent; they are unilateral or bilateral, unilocular or multilocular. They usually develop in adults, but are occasionally seen in children. Their size is exceedingly variable and they continue often to grow until it would seem the patient was attached to the tumor. It is quite common to find such a cyst containing 5 to 7 gallons of fluid, and occasional specimens are reported as weighing 100 pounds or more. The enormous mass in the abdomen necessarily causes great and increasing distress from pressure not only upon the abdominal viscera, but the thoracic as well. There are two forms of cystadenoma of the ovary, the simple form and cystadenoma papilliferum.

Cystadenoma of the breast is another frequent form, although it must be stated that the majority of mammary cysts are of the retention type. They may be single or multiple, usually the former, and quite frequently are bilateral.

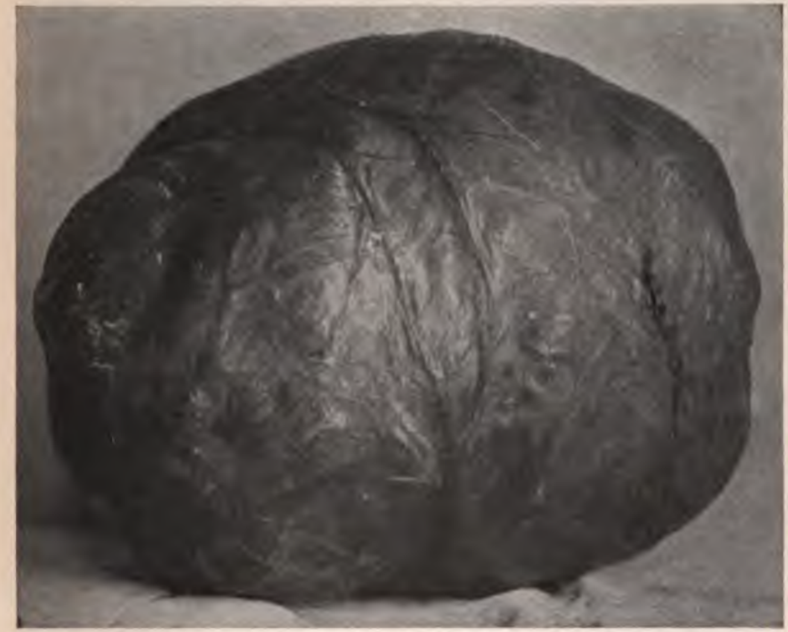

Fig. 217.—Ovarian cyst measuring nearly 2 feet in its long diameter.

Cystic sarcomata have been sufficiently discussed under Sarcoma.

Treatment.—The treatment of cystic tumors is removal. Relief of urgent symptoms from cyst adenoma of the ovary may be attained temporarily by aspiration, but this plan should never be resorted to unless celiotomy is contra-indicated.

Necrotic cysts are similar, in their manner of formation, to hemorrhagic cysts. In the latter a blood-clot, which is practically dead tissue or becomes so soon after its escape from the vessels, is dealt with precisely as the non-infected infarct or other necrotic matter is in the former. It is liquefied, the solid parts are removed, and a cyst wall forms around it, enclosing the remaining fluids. This is the type of cystic degeneration found in malignant tumors.

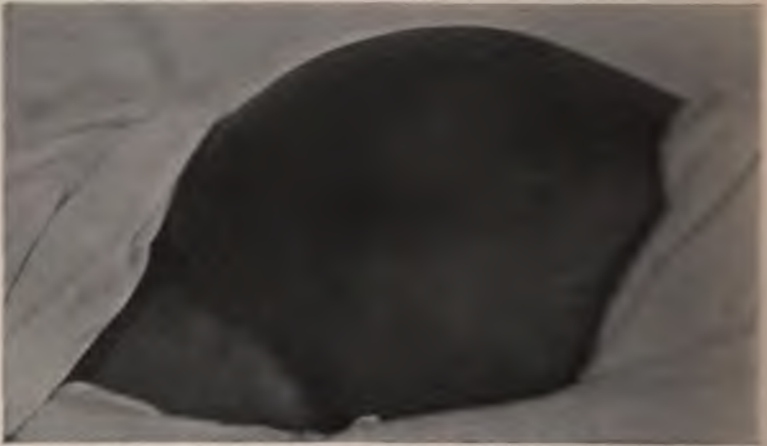

Fig. 218.—Abdomen prior to operation from which the cysts shown in Fig. 219 were removed.

Parasitic Cysts.—There are two types of parasitic cyst, namely, that produced by the dog tapeworm, Echinococcus hydatidosus, and that produced by the Cysticercus cellulosæ, representing the larval stage of Tænia solium and producing the disease known as "measles."

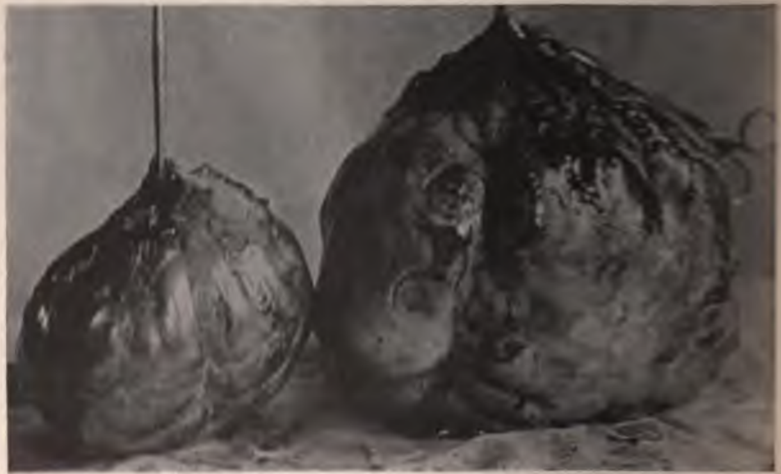

Fig. 219.—Two ovarian cysts removed from case shown in Fig. 218.

Echinococcus Hydatidosus.—This is the tapeworm of the dog, in whose alimentary tract it spends its adult stage. The larval stage is spent in another host, in whose tissues it produces echinococcus or hydatid cysts.

The eggs of the tapeworm form in the last (fourth) segment and are passed from the alimentary tract of the dog with the feces. They are then taken into the human stomach in water, on uncooked vegetables, or more directly by the filthy practices of individuals who allow their dogs to lick their hands or faces. Once the egg gains admission to the stomach, the digestive process destroys the capsule and liberates the embryo, which attaches itself to the lining of the stomach and gradually penetrates the mucous membrane and enters the blood-vessels or the lymphatic vessels, through which it is carried more or less remotely from the stomach and lodges. If the blood-vessels receive the embryos they are transported directly to the liver; if the lymphatics, the first set of capillaries they must pass are those of the lungs. This explains the frequency with which these organs are affected, as many of the organisms are too large to pass the narrow capillary lumina.

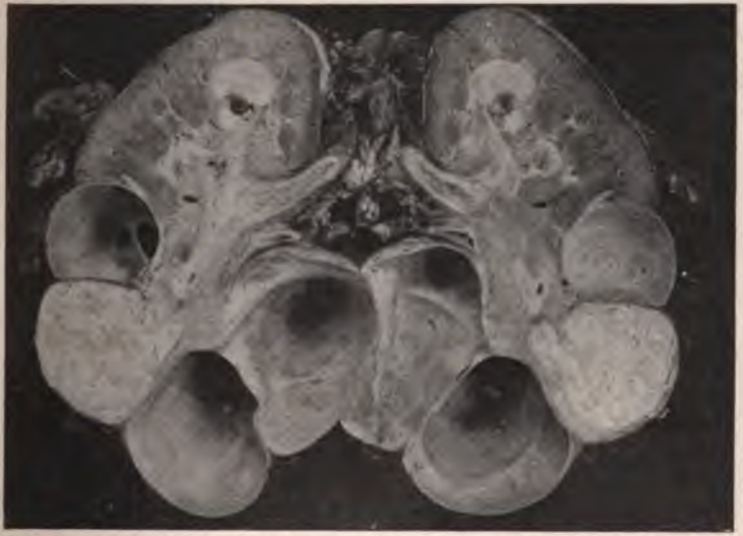

Fig. 220.—Cystic tubercular kidney. Note the large cyst above and the smaller one at lower pole filled with caseous material. (About $\frac{2}{3}$ natural size.)

Once the echinococcus has lodged, it begins to develop into a cyst. The embryo enlarges into a spheric-shaped cyst which has a wall of two layers, an outer cuticular layer of lamellated chitin and an inner parenchymatic or germinal layer of granular material. Surrounding the outer layer is a fibrous capsule such as is thrown around any foreign body in the tissues, such as, indeed, constitutes the sac of ordinary cysts. The capsule contains a fluid, usually clear, of low specific gravity (1007), containing albumin, and in the liver sometimes sugar; it furthermore contains the characteristic hooklets derived from the rostellum of the embryos. When the fluid of the cyst is evacuated the parasitic portion of the wall drops easily away from the fibrous sac afforded by the host and appears as a peculiar whitish looking membrane, which will serve to characterize the cyst even when hooklets, scolices, or daughter-cysts cannot be found.

The cyst develops for two or three months as a simple cyst and shows no contents except the fluid already mentioned (acephalocyst). By this time it has usually reached the size of a guinea-hen's egg. Then hollow processes develop in the lumen of the cyst from the germinal layer, known as brood-capsules; within these brood-capsules scolices form. These brood-capsules may become separated from the mother-cysts and lie in the fluid of the original cyst, or they may rupture and leave the scolices attached to the parenchymatic layer, or they may become detached and be free in the cystic fluid. Cysts known as daughter-cysts may form within the original (mother-cyst) from the separated brood-capsules or from the separated scolices being converted into cysts. Even within these secondary cysts others may form—granddaughter-cysts. The daughter- and granddaughter-cysts may be only a few or they may reach into thousands, literally filling the large mother-cyst.

Daughter-cysts occasionally form on the outside of the brood-capsule and gradually escape from it, so that a large number of cysts form side by side. This is the rule of formation of daughter-cysts in echinococcus of the osseous system and of the species known as Echinococcus multilocularis.

Echinococcus cysts are sometimes sterile, containing no daughter-cysts, no brood-capsules, and no hooklets.

Hydatid cysts are more frequent naturally in those countries whose inhabitants associate habitually with dogs. In Iceland it is said that one individual out of every seven is affected. They are very frequent in Australia and in certain parts of Europe. In America they are rare, being most common in Manitoba and the northwestern part of the United States.

The organs especially affected are, as has been already stated, the liver and the lungs. Other structures less frequently involved are the central nervous system, the bones, the skin, and the peritoneum. Secondary cysts may result from rupture. This fact is especially to be borne in mind in cases submitted to aspiration or operation when the original cyst lies within, or requires opening of, the peritoneal or pleural cavity.

Diagnosis.—There are no definite symptoms referable to echinococcus cysts. They develop slowly and attain a moderate or an enormous size, and kill their host in about one-half the cases in five years. They may grow intermittently. They manifest the same clinical signs found in cysts in general, with the additional sign sometimes described as echinococcus thrill, or fremitus, elicited by cross palpation. The pathognomonic evidence is the finding of hooklets in the fluid, the presence of the sac with its unique structure, or the appearance of daughter-cysts or brood-capsules. They may be single or multiple and appear in one or many organs at the same time.

Accidents.—The echinococci may die from unknown causes or during some intercurrent disease, and the growth not only be checked, but actual cure, with absorption of the fluid, sometimes takes place. The solid remains may be found in the tissues in the form of a calcareous deposit in the midst of which the hooklets can be identified. This is a fairly frequent termination.

Infection may occur in echinococcus cysts and produce the attendant signs and symptoms of inflammation. The increased tension is often responsible for rupture of the cyst and escape of its infested contents into a serous cavity or blood-vessel, with the severe and fatal symptoms which necessarily follow such an accident.

Rupture of echinococcus cysts may occur spontaneously or as the result of accident. This causes diffusion of the echinococci into the surrounding structures or spaces and is followed by the development of new cysts. The peritoneum or pleura may in this manner, or by leakage following aspiration, or by accidental escape during operation, become literally filled with cysts. Another result of rupture is the appearance of urticaria; this symptom sometimes follows aspiration of a hydatid cyst and is then considered pathognomonic. Rupture into the peritoneal cavity is followed either by insignificant symptoms or by severe symptoms of a toxic nature, as collapse and syncope, which may terminate in death. Peritonitis may follow rupture into the peritoneum. Cysts in which the echinococci have died are said to produce the more violent symptoms when rupture into the peritoneum occurs, rupture of the living cysts causing milder symptoms (Rolleston).

Prognosis.—The presence of an echinococcus cyst may be of little significance if it be taken in hand early and properly treated. The fact that nearly half of the echinococcic patients die within five years is sufficient comment on the inadvisability of leaving them untreated. The chance of spontaneous cure is too small to be relied upon. The danger of spontaneous or traumatic rupture is always present, and the possibility of infection remains a menace to the patient's life. Aspiration across a serous sac for diagnostic purposes adds to the unfavorableness of the prognosis, and if done the needle should not be withdrawn until surgical intervention has been done.

Treatment.—The ideal treatment is to remove the cyst entirely from the fibrous capsule which ensheaths it, having the utmost care not to permit the contents to escape into the field of operation. If for any reason removal cannot be accomplished, marsupialization may be done at one or two sittings, and the cavity packed and caused to heal from the bottom.

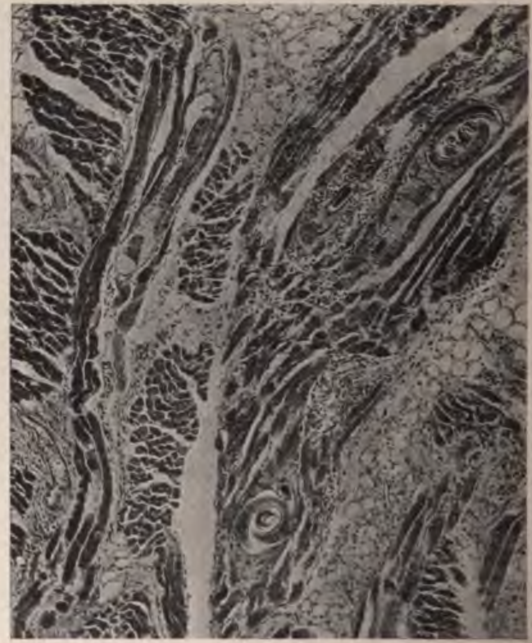

Fig. 221.—Trichina spiralis. (Microphotograph; × 65.)

Echinococcus of bone may require simple removal, r
or amputation, as the circumstances determine.

Cysticercus Cellulosæ.—This form of cyst is of
tively little practical concern to the surgeon. It is p
the larval form of the Tænia solium, or pig tapeworm
much more frequently in the flesh of hogs than else

constitutes what is known as measley meat, the individual nodules being spoken of as "measles." The adult worm is found in the alimentary tract of man. When the eggs are carried into the human stomach the larval form appears in man, being found in the muscles, subcutaneous connective tissue, the brain, its membranes and ventricles, in the eye, in the heart muscle, and rarely in the liver or lungs. They appear in great numbers and widely distributed throughout the body. The eggs are taken into the stomach from without or are brought into the stomach by regurgitation from the alimentary tract of hosts of Tænia solium, and follow then the same course of entrance and distribution as the Tænia echinococcus. They develop into small cysts whose sac is made of new-formed connective tissue. The cysts vary in size from that of a pea to that of a hazelnut, and may live in great numbers in the tissue through their full life cycle, from three to twenty years, without producing symptoms. Naturally, when the eye or the brain is affected special symptoms may arise. Weakness of the muscles appears when large numbers of the cysts develop.

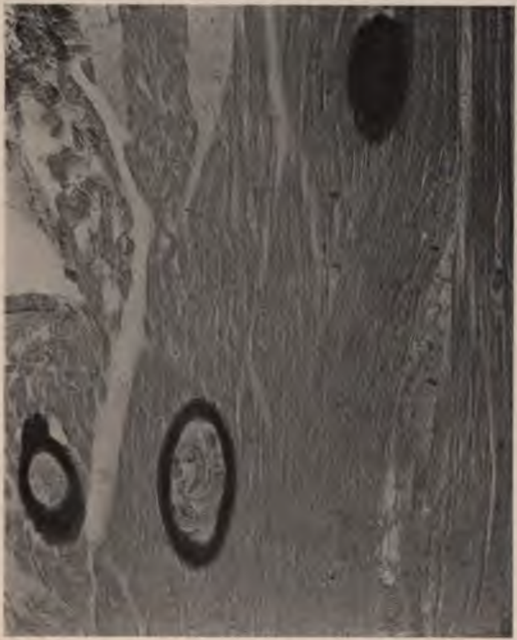

Fig. 222.—Trichina spiralis. Chronic case. Note heavy deposit of calcium salts around larvæ. (Microphotograph; × 65.)

Treatment.—The disease is self-limited and may require no treatment. If inconvenience is produced by the disease, the particular nodules causing the symptoms are to be removed by excision.

Dermoid Cysts.—In order to make the situation clear, it is necessary to discuss briefly the more comprehensive group of abnormal growths to which dermoids belong, namely, teratomata. The word signifies "monstrosity," but its application pathologically is much more comprehensive than the limited group of specimens which originally gave origin to the word. A teratoma is a congenital and permanent combination of a greater or smaller amount of tissues or organs of one individual with another. As examples may be mentioned the cases of monochorial or dichorial twins and those in which parts of one individual are attached to another, as an extra pair of legs or arms or an extra head. These represent monsters pure and simple. But when one is concealed in the tissues of another, they represent the group with which we are especially concerned at present.

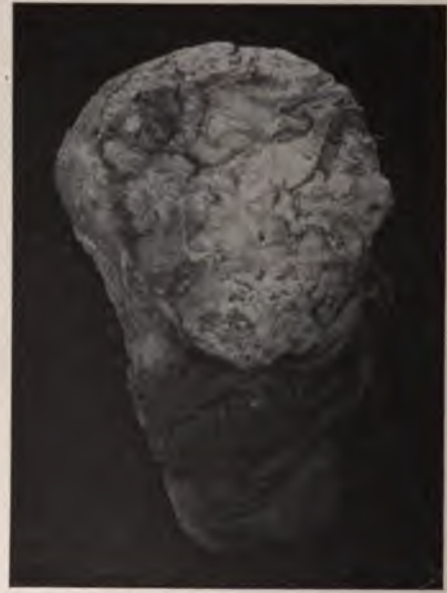

Fig. 223.—Teratoma testis.

Origin.—It is impossible to discuss in detail the numerous theories that have been offered in explanation of the origin of these remarkable growths. Only the most probable explanation will be given. There is no doubt that teratomata represent the growth of one individual more or less complete within another which serves as host. The source of this growth according to the most plausible theory (Adami) is that germinal blastomeres, which belong to the group of cells known as totipotent, become displaced and ultimately develop into a teratoma. These cells are more abundant in the testicle and ovary, hence the great frequency of teratomata in these organs, but they may be remotely displaced and be responsible for the occasional development of such growths about the head. These totipotent cells are the ones which transmit the capacity to reproduce all types of cells, and it is consequently from them that the ova and spermatozoa are formed. These latter, however, require fertilization to assume their rôle of reproduction, so that the blastomeres which form embryomata must be more elemental than these specialized forms, for the former have the power of parthenogenetic development.

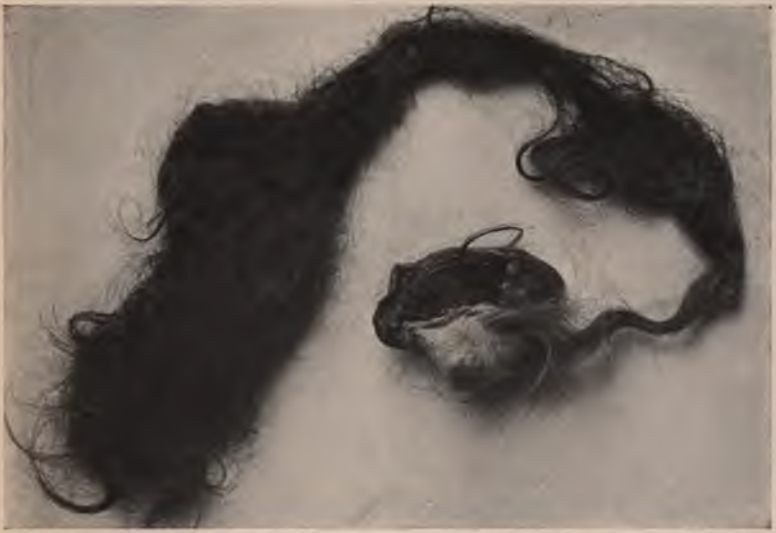

Fig. 224.—Hank of hair 22 inches long removed from large intra-abdominal dermoid.

Structure.—The simplest form of dermoid (skin-like) cyst is one containing a caseous material such as that found in sebaceous cysts or in the sequestration cysts which are often classed as dermoids. In others the lining of the sac may have advanced a step further in its resemblance to the skin, and contains sweat-glands, sebaceous glands, and hair-follicles with hairs growing from them. In yet other cases additional structures appear, as mucous membrane, connective tissue, bone, teeth, nails, nerve tissue, and, rarely, other structures. The hair may be attached or lie loose in the cyst cavity; it may be abundant or scant. Occasionally there are shown in the cyst evidences of an attempt to develop certain more complex structures, such as mammary glands.

These structures are either solid or cystic. In the former case they are usually small; in the latter they may attain an enormous size, but large size is found only in dermoids of the ovary.

Dermoid cysts grow slowly, and are to be recognised by their location, their slow growth, small size (except ovarian dermoids), and their signs of cystic structure. They may be present from birth, but frequently begin to grow only at or soon after puberty. As the patient grows old the dermoid may shed the attached hair, leaving bald spots. The hair of these cysts also may become gray with the advent of old age.

Ovarian dermoids or broad ligament dermoids when uncomplicated produce usually moderately large cysts, rarely larger than a human head. The very large cysts are usually not pure dermoids, but are associated with a cystadenoma. Dermoids of the ovary are usually unilateral and unilocular.

Dermoid cysts of the ovary are especially apt to become inflamed, rapidly enlarge, and produce extensive adhesions.

The most important complications of dermoid cysts are inflammation and the development of cancer; the former is frequent, the latter rare.

Dermoids are found with greatest frequency in the ovary, the testicle, the sacrum (inclusion or sequestration cysts), and in the face, especially at the outer angle of the orbit. They are rarely found in the thorax or upon the surface.

Treatment is removal.

Traumatic Inclusion Cysts.—Traumatic inclusion cysts result from the implantation of portions of skin into the subcutaneous tissues, as, for instance, when a blunt nail or punch is driven into a part. The transplanted skin behaves as a graft. It produces its normal secretion and gradually assumes a rounded form, and finally, by proliferation of its epithelium and the formation of scar tissue, forms a closed sac. The contents are the same in appearance as in sebaceous cysts, but inclusion cysts may contain hairs. They are usually found on the hands.

Treatment is excision.

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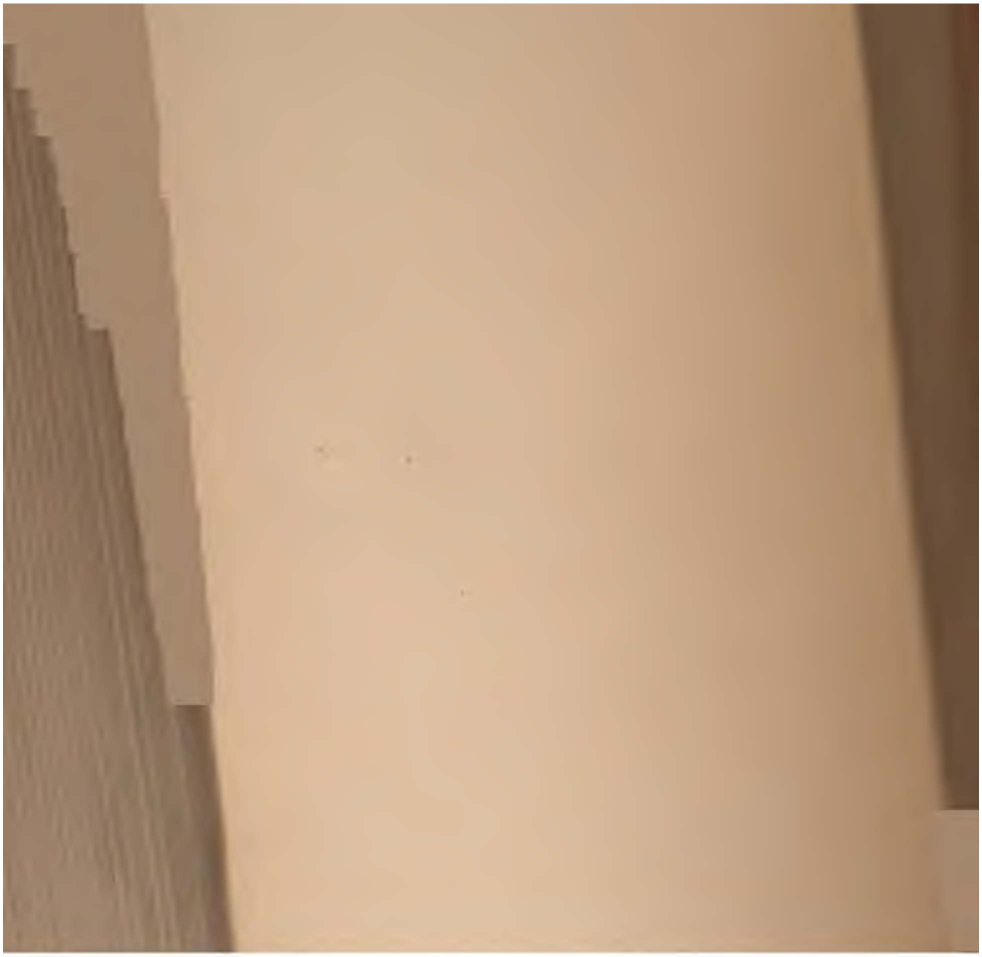

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